U.S. Army Corps of Engineers
Water Resources Support Center
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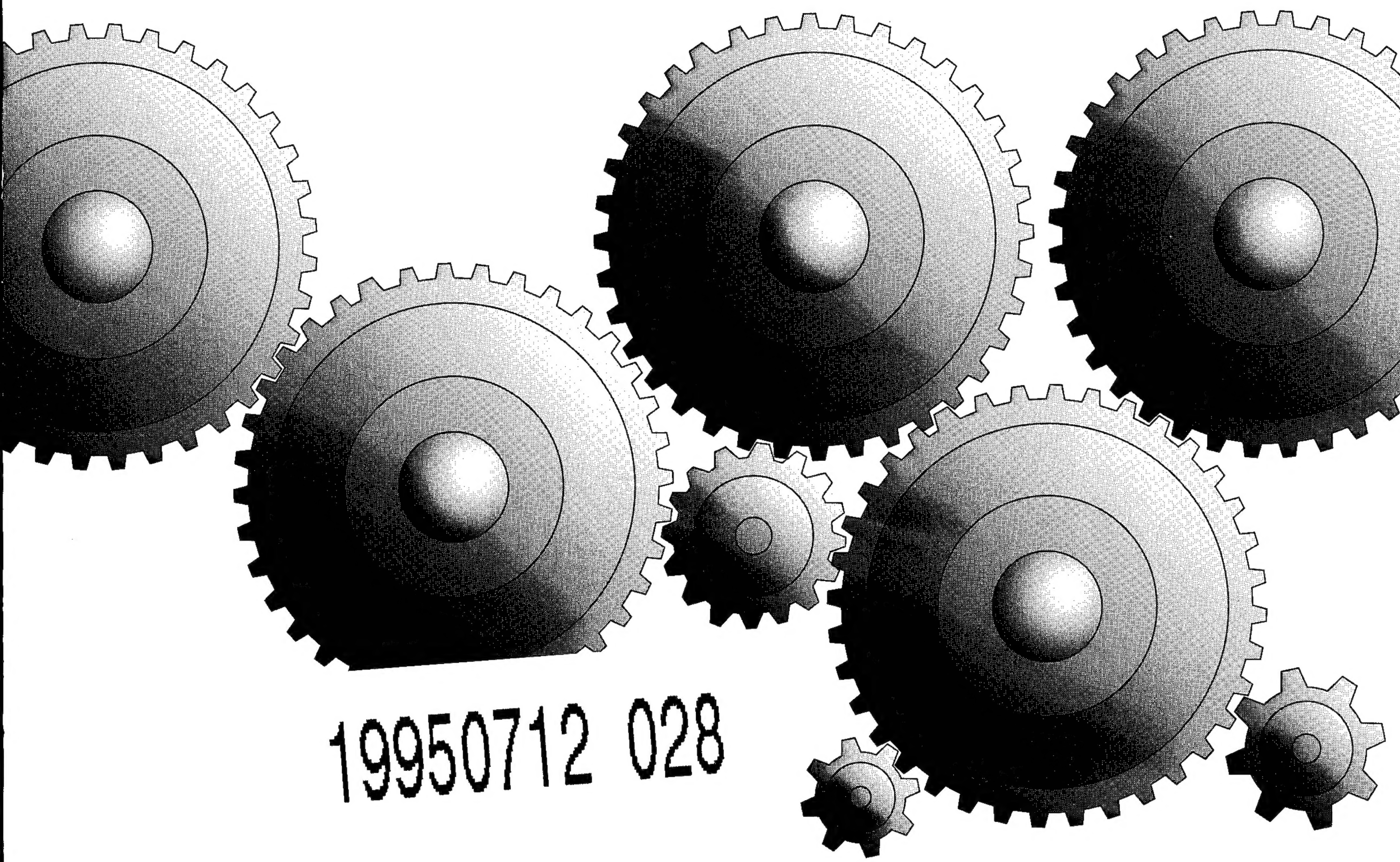
THE URBAN INSTITUTE

ISSUES IN DEFERRED MAINTENANCE



Federal Infrastructure Strategy Program

November 1994

IWR Report 94-FIS-16

Federal Infrastructure Strategy Reports

This is one in a series of reports prepared as part of the Federal Infrastructure Strategy (FIS) Initiative, a 3-year program to explore the development of integrated multi-agency Federal infrastructure policies.

The Federal Infrastructure Strategy was a dynamic program involving many Government departments and agencies. The series of reports which chronicle the strategy's development reflect the desire to publish interim documentation as results become available. These documents have been used to facilitate the dialogue within the Federal and non-Federal infrastructure communities as policy deliberations continue. A complete list of FIS documents to date can be found on page 93.

The program will culminate with a concluding report to be published later in 1994. The documentation contained herein is not intended to foreclose or preclude the program's final conclusions and recommendations. Within this context, comments are welcome on any of these reports.

This report, *Issues in Deferred Maintenance*, provides the Federal Infrastructure Strategy Initiative with a description of the current state of knowledge of measuring and managing the impacts of deferred maintenance. The analysis, conducted by The Urban Institute, includes information gathered from federal, state, and local agencies representing a broad range of populations, geographic locations, forms of governance, and functions. It also reflects a review of the policy literature.

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The Institute's infrastructure study team also included Dr. Cameron E. Gordon, Economics Studies Manager and Mr. James F. Thompson, Jr., Engineering Studies Manager. The program was overseen by Mr. Kyle Schilling, Director of the Institute.

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The Federal Infrastructure Strategy Program

Issues in Deferred Maintenance

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for

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ISSUES IN DEFERRED MAINTENANCE

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ACKNOWLEDGEMENTS

This report presents the results of an inquiry into issues surrounding deferred maintenance of infrastructure undertaken for the U.S. Army Corps of Engineers under a broad administrative directive aimed at the development of a Federal infrastructure strategy (FIS).

The FIS program was administered by the Corps as a collaborative interagency effort supported by a series of expert inquiries and research papers. The study presented here was conducted by Harry Hatry and Blaine Liner of The Urban Institute. The Corps of Engineers expresses its sincere appreciation to The Urban Institute and all who participated in the study. Special thanks to the intergovernmental advisory panel (see below) and the agencies and local governments that hosted the various case studies.

Policy guidance for the FIS program was provided by the Office of the Assistant Secretary of the Army (Civil Works), while program execution is overseen by the Corps of Engineers Directorate of Civil Works through Donald Kisicki, Chief, Office of Interagency and International Activities.

The Corps Institute for Water Resources (IWR) had detailed management responsibility for the FIS program under the direction of Kyle Schilling, Director of the Institute, Eugene Stakhiv, Chief, Policy and Special Studies Division, and Robert Pietrowsky, FIS Program Manager. This report was prepared under the supervision of Cameron Gordon, who also wrote the introduction. Special thanks are given to Arlene Nurthen, IWR, for her efforts in editing and formatting the final report.

Note By Study Authors:

The Urban Institute study authors, Harry Hatry and Blaine Liner, are pleased to acknowledge the participation and contributions of many helpful individuals to our project. We were ably served by an advisory panel of individuals who have long been associated with questions and issues concerning the public's infrastructure. This panel met with us in a formal sense twice; many members were in frequent contact with us throughout the project period. The advisory panel members included:

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Mr. William Monroe, a student at Duke University, was an intern assigned to the project. He helped develop the early case study descriptions and conducted a major literature review. Rosetta Swann, staff assistant in the State Policy Center of The Urban Institute, provided support services throughout the project.

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ISSUES IN DEFERRED MAINTENANCE

EXECUTIVE SUMMARY

This report presents the findings from an examination of public agency practices (federal, state, and local) in analyzing and reporting deferred maintenance on their facilities, such as roads, bridges, buildings, water or sewer systems, etc. The study team examined existing literature (the results of which are presented in detail in a separate report), and followed up on a small number of past and active federal, state, and local agency efforts (including field visits to review the activities in New York City and San Jose, California).

The study revealed a highly limited amount of either literature or actual ongoing efforts by public agencies directly addressed to the analysis and reporting of deferred maintenance.

A consensus appears to exist that "deferred maintenance" should be defined to mean that maintenance and repair needed to bring current assets up to at least a minimum-acceptable physical condition level. Improvements in the asset's capacity or its capability over the original intent for the assets should not be included. Deferred maintenance is usually expressed in reports as the cost to bring assets back to an acceptable physical condition. The needed repairs can include costs that are considered to be capital costs. That is, costs are not limited to only those funded out of operating budget appropriations.

The literature and field interviews make a strong case for reporting annually the amount of deferred maintenance. Such information is needed for proper stewardship of public assets and can provide needed information to public officials to help them make more informed judgments as to the allocation of scarce public resources. Public agencies should, each year, provide to their elected officials and the public, defensible information as to the implications of deferring maintenance on the assets managed by those agencies.

Four basic analytic steps were identified for the full reporting of deferred maintenance:

(1) assessment of the condition of the assets;
(2) determination of a minimum acceptable condition level for each type of asset;
(3) estimation of the cost to bring those assets back to acceptable condition; and
(4) estimation of the consequences of deferring maintenance.

The state of knowledge and techniques for accomplishing these steps differs significantly among various types of infrastructure. This study focused primarily on roads, water and sewer systems, and building-like structures. Clearly, the current ability to provide accurate information as to the magnitude of deferred maintenance and its implications differs widely among facility types. Governments at all levels that aggregate their deferred maintenance needs across different types of infrastructure will need to

recognize that estimates for the different types of infrastructure will be based on somewhat different procedures and have different levels of uncertainty. An important need often pointed out in the literature and in the interviews is the need for a government and its agencies to establish common groundrules/guidelines, such as for establishing minimum acceptable condition levels -- to help reduce potential differences among their components and types of infrastructure.

Of the four steps, the first and third, condition assessment and cost estimation, are by far the most prevalent at all three levels of government. The other steps are done much less frequently. An issue for cost estimation is whether the costs should be the minimum needed to bring the asset back to an acceptable condition or, rather, should be based on an "optimal" maintenance strategy that takes into account long term costs. (The latter approach, while ideally preferable, may not be feasible, at least for some types of infrastructure.)

Determination of a minimum-acceptable condition level seldom appears to be done by government agencies, at least not in a systematic manner. Even for road maintenance, where considerable condition assessment has been done nationally, establishment of acceptable condition levels is rare. When done for any type of infrastructure, the primary approach used has been to provide best-judgment, engineering estimates. Procedures that involved customer opinion and the explicit assessment of level of service and risk implications were not generally found to be in current use by public works agencies.

Estimates of the cost and service quality implications of maintenance deferral were rare, especially the latter. Public officials appear to believe such information to be of considerable use; dollar estimates of the magnitude of deferred maintenance, alone, was not felt to be sufficiently informative. The officials interviewed were more impressed with cost-avoidance estimates than estimates of service quality impacts, probably because most of the information provided on quality impacts has been highly general without specific evidence. Information on both types of implications seem highly desirable in order for public officials to be able to allocate resources in a more informed way.

Cost-avoidance estimates have been most often used for road maintenance (where work has been done on deterioration rates). A small amount of work has been done to develop deterioration rates for various types of sewer pipe, and very little, thus far, has been done for buildings. Deterioration rates appear to be essential to making cost-avoidance estimates.

The state-of-the-art is quite weak for estimating service-quality implications for most types of infrastructure, such as water and sewer systems and building-like structures. For highways and roads, however, deterioration curves are used to predict the road surface quality. The relation to ride quality, safety, and driving costs, while not well established, permits some estimation of effects of poor roadways on service quality.

The few agencies that were found to be reporting figures relating to the magnitude of deferred maintenance reported overall totals, broken out by type of infrastructure. Thus far, agencies have generally not attempted to break these figures out by degrees of importance, such as breakouts based on the magnitude of cost avoidance and service quality implications (probably because, as noted above, such information usually has not been available).

RECOMMENDATIONS

Suggestions for Governments and Agencies

The following recommendations are presented as basic overall suggestions. More detailed suggestions are provided in the discussions of individual issues.

1. Public agencies at all levels of government (federal, state, and local) should develop a process for reporting annually their best estimates of the amount of deferred maintenance (i.e., maintenance backlog), expressed as the estimated costs to bring assets to a minimum-acceptable condition level. This information should be used to: help individual agencies establish their priorities; help public officials to make resource allocation decisions as to where funding should be placed; and provide basic information that enables elected officials and the public to understand the extent to which funding decisions are associated with important backlogs.

2. Deferred maintenance should be categorized into at least two categories of degree of importance. Importance should not be based solely on the principle of "worst first" but should consider the importance of the item to service quality and health and safety. The government and agency should establish at least a semi-structured procedure for establishing importance ratings (such as that used by the U.S. Department of Energy) even if it is necessary to rely on primarily qualitative/best expert judgment information.

3. In addition, governments and their agencies should be asked to provide information on the implications of continued deferral. To the extent feasible, this information should be provided both on: (a) the amount of added cost that would be incurred; and (b) the impacts on service quality, health and safety of such deferrals. The latter information currently is likely to be available only in a highly limited way. (Later recommendations address this gap.) While the amount of deferred maintenance is important in itself, without also including information on the implications of deferral, public officials and the public will have considerable difficulty in interpreting the deferred maintenance figures. At the very least, program personnel should be asked to provide their best informed judgments as to the likely impacts on service quality of deferrals. The more the program can back up these qualitative judgments with hard evidence, the more credible and effective this information will be to those responsible for allocating funds.

4. Governments with many different agencies, and agencies with many different programs and facilities, should at the beginning of each year provide common ground-rules and guidelines to their various units on: (a) what is to be defined as deferred maintenance; (b) what should be the standard for

minimum-acceptable condition for major types of assets; and (c) what information is requested on the likely implications of deferrals for each major category of deferred maintenance.

5. Governments, their agencies, and the developers of the various maintenance management systems should build into these systems provisions for providing annual year-end estimates of the amount of deferred maintenance and the cost to bring that amount up to a minimum-acceptable condition level. These models should also provide estimates of costs that would be avoided if early maintenance is provided and, to the extent possible, information on the effects on service quality of deferrals (such as extent of deterioration in ride quality for pavement repair deferrals).

6. Since the potential cost of condition assessment can be major if an agency attempts to cover annually 100% of its assets, agencies should consider a stratified sampling approach for condition assessment. The agency would identify those asset components at most risk, considering such factors as materials, loadings, age, and importance of the asset. The annual samples for at-risk assets would be large, as compared to new or lesser-importance infrastructure.

Suggestions for National Research and Development and Information Dissemination Efforts

A basic theme of these recommendations is that it is highly inefficient and a waste of valuable resources for each government and each agency to undertake its own development work (which is both time consuming and often quite expensive), especially for developments relating to common types of infrastructure such as pavements, water and sewer pipes, buildings, bridges, etc.

7. A comprehensive survey and follow-up of federal, state, and local agencies (at least the larger local agencies) should be undertaken to identify the current status across the country in their use of procedures needed for estimating deferred maintenance, such as for:

   - condition assessment;
   - identification of minimum acceptable levels of condition;
   - estimating the costs to bring assets that are below acceptable condition level to an acceptable level;
   - estimating the future added cost due to deferrals, including use of asset-deterioration curves; and
   - estimating the extent to which service quality, and health and safety impacts of deferrals are systematically examined and reported.

   The survey would need to be done for each major type of infrastructure. This effort should also seek to identify effective, successful procedures and disseminate these to other agencies.

8. Maintenance management systems being developed for national usage should be modified so as to be able to provide year-end estimates of the amount of deferred maintenance, estimates of potential added costs from deferral, and to the extent possible, estimates of the reduction in service quality, health, and safety due to deferrals.

9. The weakest link in the analysis and reporting of deferred maintenance is the limited information currently available on the implications of deferred maintenance for various types of infrastructure. A national effort is desirable to identify ways to better estimate added costs from deferrals of maintenance for major categories of infrastructure and of deferrals' impacts on service quality, health and safety. Problems differ significantly among different types of infrastructure. The development work needs to be tailored to specific types of infrastructure.

Statistical procedures might be undertaken nationally on major categories of infrastructure, such as pavements, building components, sewer pipes, etc., to identify deterioration rates. Some of this, in effect, is already being done, such as the research on the effectiveness of different types of pavements. It seems likely, however, that such efforts do not adequately take into account the questions and implications of maintenance deferrals. Such efforts will not be easy. Numerous factors affect deterioration, including weather, soil conditions, and loads. This implies numerous variations, but proper statistical design should help to provide valuable insights to the deterioration science implications of potential deferral maintenance policies.

INTRODUCTION

INFRASTRUCTURE MAINTENANCE AS A BUDGET PRIORITY: AN OVERVIEW

All actions have consequences. From the perspective of the public works manager, one of the prime consequences of constructing a new facility comes years after it is built when age brings on ailments that need to be fixed, and wear and tear wreaks decay which must be renewed.

When a facility is new, thoughts of operations and maintenance requirements are often far from the minds of public officials, citizens and agency functionaries. However, much of America's infrastructure is no longer new anymore.

America's Aging Infrastructure

Systematic and centralized information on the age of infrastructure facilities is surprisingly hard to come by, but the information which does exist shows the extent to which many of the nation's public works are graying at the temples. For example, in 1970, the net stock of public residential housing capital owned by all levels of government, had an average age of 12.7 years. By 1991, the average age had risen to 14.7 years.[1] Around 40 percent of the lock chambers in Inland Navigation System are over 50 years old, with the oldest lock, on the Kentucky River, being 150 years of age.[2]

The Increasing Role of Maintenance

The increasing age of much of the nation's public capital logically implies that a greater share of the money spent adding to that stock should be going to maintenance rather than new investment. The numbers largely confirm this expectation. Consider spending in the United States for public works between 1960 and 1990 (see Exhibit 1-1). In 1960, the nation spent $63 billion in nominal dollars at all levels of government on public works for highways, mass transit, rail, aviation, water transport, water resources, water supply, and sewage treatment, Of that amount, almost three-fifths of that money was devoted to new capital investment, with the remaining two-fifths going to noncapital spending. America was beginning to build its Interstate Highway System, and a growing population in flush economic times required the construction of new public works systems all over the country.

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[1] 1992 Statistical Abstract of the United States, Table 1232.

[2] U.S. Army Corps of Engineers, The 1992 Inland Waterway Review, (October 1992).

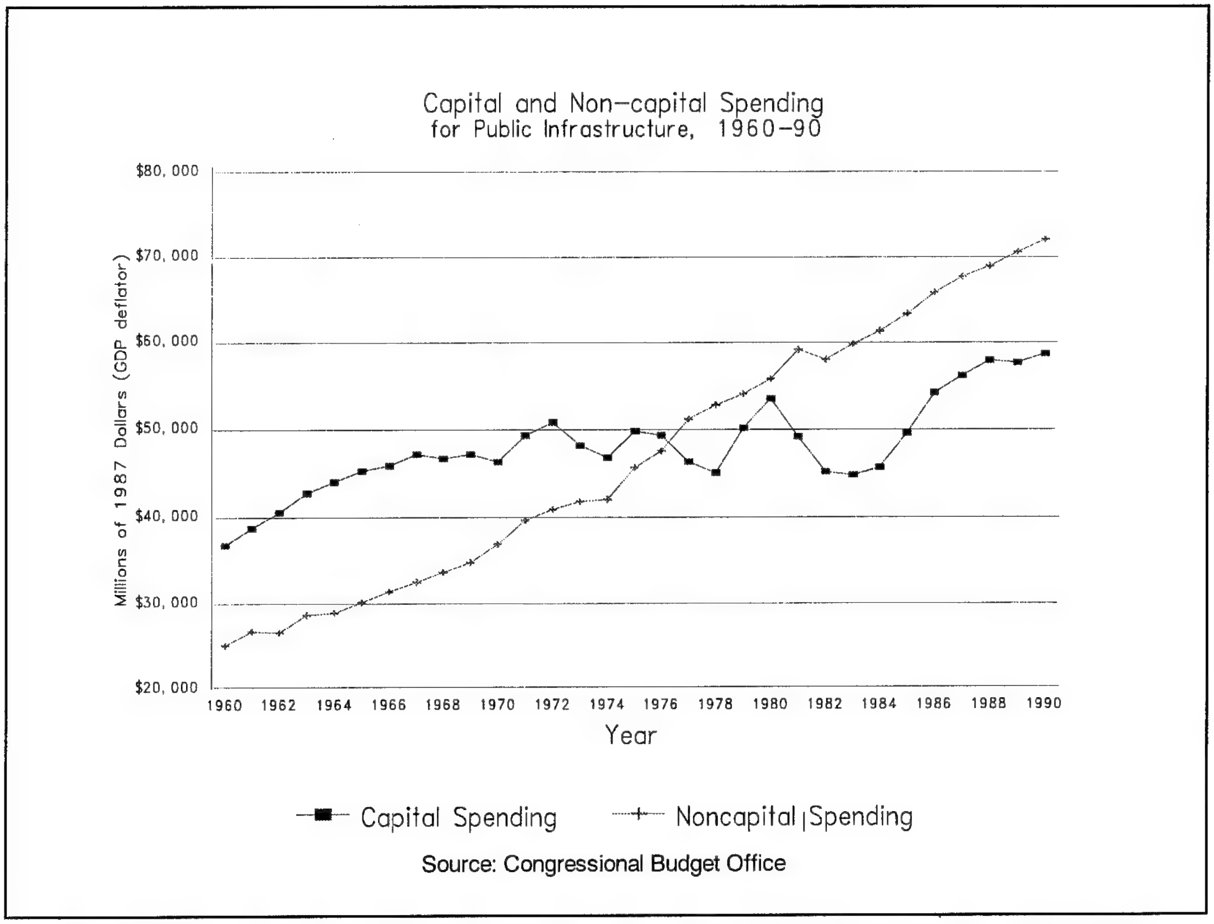

Exhibit 1-1 - Capital and Non-Capital Spending for Public Infrastructure, 1960-1990

By 1990, the nation was spending $130 billion on these same public works categories. However, now the relative importance of maintenance spending vis-a-vis new capital spending had been reversed, with the proportion of noncapital spending accounting for more than 55% of the total infrastructure budget.[3] Much of the nation's infrastructure had already been constructed and does not need to be rebuilt again. Instead, the challenge has become to maintain investments which are already in place.

To be sure, this shift towards maintenance has not affected all infrastructure modes equally. Exhibit 1-2 displays the average percentage of total spending in the infrastructure categories mentioned which were devoted to noncapital spending during the periods of 1960-70, 1970-1980 and 1980-1990.[4]

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[3] The data presented here, and much of the discussion of modes which follows, is taken from "Trends in Public Infrastructure Outlays," U.S. Congressional Budget Office Staff Working Paper, 1993.

[4] This table excludes the category of railways because overall spending on this mode is very small relative to other modes and because budgetary anomalies make the numbers difficult to interpret.

EXHIBIT 1-2
AVERAGE SHARE OF TOTAL SPENDING
(LOCAL,STATE AND FEDERAL)
DEVOTED TO NONCAPITAL PURPOSES

	1960-70	1970-80	1980-90
HIGHWAYS	36.5%	44.7%	50.6%
MASS TRANSIT	86.0%	79.9%	79.6%
AVIATION	75.4%	76.2%	73.7%
WATER TRANSPORT	72.5%	74.8%	76.4%
WATER RESOURCES	35.8%	49.4%	56.6%
WATER SUPPLY	57.3%	65.4%	70.2%
SEWAGE TREATMENT	35.5%	38.3%	53.2%

The budgets of highways, water resources, water supply and sewage treatment became increasingly consumed by noncapital spending between the 1960-70 and the 1980-90 periods. For example, while a bit more than one-third of highways spending went to noncapital purposes during 1960-70, more than half of the total was so devoted between 1980-90. Similar, if somewhat more dramatic, stories can be told for water resources and sewage treatment. The public sector dominated these three types of investment during the 1950's and 1960's, mainly focusing on developing new resources. Now that involvement has shifted to the management and care of what is already out there.

Noncapital spending has also increased in the water transport and water supply categories, although in these cases, noncapital spending has always been significant and hence the proportional shifts away from new investment less dramatic. In part, this is due to the fact that the nature of public sector involvement in these areas is different than in other areas, with private sector sources providing more of the new capital investment in industries such as water supply.

The nature of public policy also accounts for some of the differences in relative shifts in capital to noncapital spending across sectors, as made clear by the decline in noncapital spending in mass transit between 1960 and 1990. In this case, federal government operating subsidies to transit operators rose during the early 1970s and then fell back. Mass transit is perhaps the only public sector program to have provided significant operating assistance to infrastructure agencies for any length of time.

Despite the variation across spending categories, it is clear that noncapital spending for infrastructure has steadily grown in importance over the last 35 years and that much of this increase has been driven by the fact that the construction of the large national transportation and environmental protection systems are largely complete. Some parts of these networks, particularly in fast growing areas of the country, still need to be completed, but a significant capital stock is in place, it is getting older, and it needs to be cared for.

Infrastructure Age and Infrastructure Services

Whatever the age of the facility, infrastructure is not an end in itself but a means of delivering services which the public desires. With a well-designed and soundly-constructed new installation, the connection between the investment and final services is very close: the facility is designed to perform at a certain level for a specified cost, and if operated properly that is what it does.

Age complicates this relationship. With wear and tear, performance becomes harder to maintain. Additional investment, in the form of maintenance and repair, becomes necessary. Eventually, there may be the need to rehabilitate a facility or even to replace an investment entirely.

But when should this incremental investment be made, and how large should it be? It can be problematic to assess "optimal" maintenance strategies, i.e. investing just enough to avoid more costly operations failures in the future, but not so much that the level of service being delivered is not high enough to justify the expenditure. In the public sector, budgets at all levels of government are heavily constrained, and there are many competing demands for funds besides infrastructure, some of which (such as urban poverty or health care) often seem especially urgent in comparison.

Moreover, poorly maintained infrastructure systems can usually deliver minimally acceptable service levels for long periods of time, even though the deferral of needed maintenance is almost always a loser's game, costing much more over time in terms of reconstruction and extensive repair than a sound incremental maintenance strategy. In an annual budget cycle, with tight budget ceilings and pressing needs such as police protection demanding resources, the pressure is enormous for the policymaker to say, "the bridge isn't falling down yet; let's defer that paint job for one more year and use that money to oil the many squeaky wheels around here."

Put it all together - an aging infrastructure, a tight public budget, and the subtle and unexciting payoffs to maintenance - and the product which results is often deferred maintenance.

A Study of Deferred Maintenance

Thus it was that the U.S. Army Corps of Engineers, Institute for Water Resources, through its Federal Infrastructure Strategy (FIS) Program, asked The Urban Institute to (1) make a brief examination of current deferred maintenance reporting practices; (2) convene an interagency, intergovernmental panel to look at the issue; and (3) suggest ways of improving public sector decisions regarding maintenance of their public works.

Deferred maintenance, often referred to as unfunded or unaccomplished maintenance or backlog, has not been a popular or frequently discussed topic in the literature. It is, however, a major topic, if only implicitly, in most public agencies' annual planning and budget preparations. It is the fortunate agency, indeed, that can always fund all its maintenance needs, and, thus, has no concerns about deferred maintenance.

For the other less fortunate public agencies, the following sections identify and discuss a number of the basic issues that agencies need to address in their examination of their deferred maintenance situation. The thrust of this report is that agencies should establish a systematic and, at least partially, standardized

process for calculating and subsequently reporting the amount of needed maintenance and the cost of bringing their assets up to a minimally-acceptable condition -- and on the implications if such funding is not provided. The implications are not just fiscal; they include other important considerations like service quality, and health and safety.

Deferred maintenance is, of course, only one of many concerns that public agencies have about their infrastructure. This report does not address concerns about choices relating to growth and increased capacity. Nor does it examine directly such topics as: choosing among alternative maintenance options (though as will be discussed later, this can affect some deferred maintenance calculations); the desirability of choosing construction or major rehabilitation projects in a way that considers maintainability and life cycle costs -- as a way to keep down future maintenance needs and, thus, the possibility of future deferred maintenance; nor does it examine project planning and scheduling of maintenance projects.

This is an exploratory study. It describes issues that relate to accounting, analysis, and reporting of public sector deferred maintenance. Because of resources and scope limitations, extensive surveys of the activities of federal, state, and local agencies that relate to deferred maintenance were not possible. Nor were any specific type of infrastructure such as roads, or water and sewer systems, or building-like structures examined in great detail. For example, the numerous infrastructure management systems being developed for federal, state, and local agencies to analyze maintenance needs for pavements, sewers, etc., could not be surveyed or documented.

As part of the study, The Urban Institute conducted a survey of existing literature on the topic of deferred maintenance to identify what was already known about the topic. As it turned out, while there was a plethora of information on maintenance topics such as condition assessment and cost-effective replacement strategies, there was very little study of the costs and implications of deferring maintenance. In other words, there appear to be no standard methods for estimating how much additional future costs will be incurred by a decision in the present to defer maintenance on a particular facility.

Much of the available information focuses on classification and depreciation of particular types of assets rather than on the level of service delivered by an entire system. The one exception is a new accounting system being tested in Britain called renewals accounting which seeks to estimate the amount of incremental investment flows necessary to keep a public works network such as a water system delivering a specified level of services (for example, x amount of clean water delivered reliably to y number of customers each year). Conceptually, this approach does not seek to estimate asset life or depreciation rates, shifting instead from a focus on component parts of a system to a focus on what that system delivers at the end of the day.

The focus on services - in effect the performance - of public works systems was the framework which the Urban Institute adopted for the panel discussions and further research which followed. The Urban Institute cast a wide net, but more closely examined a number of particular cases. These cases ranged from local governments to Federal agencies, in a variety of settings and geographical locations. The intergovernmental panel met twice to discuss the policy implications of the work completed by The Urban Institute study team. Panel members also participated in and reviewed the research on the "case studies" and, with The Urban Institute's help, recommended a series of issues which public policymakers need to address when considering deferred maintenance.

This report draws from: (a) the literature review contained in a separate volume "Literature Review on Deferred Maintenance" (July 1994)"; (b) an examination of the deferred maintenance analysis processes of New York City (focused primarily on buildings, but also road maintenance), the City of San Jose (CA) -- with particular focus in this report on its sewer maintenance work; and the U.S. Department of Energy (involving some, but limited, on-site work -- focusing on its various facilities); (c) limited examinations of deferred maintenance related efforts of the State of Connecticut's Department of Transportation, the City of Dallas (TX), and the U.S. Army Corps of Engineers (such as its BUILDER project and its work on a uniform backlog reporting system); (d) discussions with staff of the American Public Works Association; and (e) suggestions provided by the project's advisory group. The three sites in (b) were among the very few the study team was aware of that had advanced processes in place for analyzing maintenance needs.

The list of issues discussed in the report is shown in Exhibit 1-3. The following fourteen sections address each of these issues. This is followed by a discussion of the special problems and procedures unique to particular types of infrastructure, particularly roads, water and sewer systems, and buildings. The second half of this volume presents an annotated bibliography, "Literature Review on Deferred Maintenance."

The clear theme of the report is that infrastructure maintenance is an ever more pressing need and one that must be given as careful consideration as other pressing public works issues. Decisions about the level of resources to be devoted to maintenance may never be easy, but they must be made, and preferably not by default as they so often are made now.

Exhibit 1-3:	**List of Issues**
Issue 1:	What is the relevance and importance of deferred maintenance?
Issue 2:	How should "deferred maintenance" be defined?
Issue 3:	The need for condition assessments: Is sufficient condition assessment information available?
Issue 4:	How should benchmarks/standards be established for acceptable condition levels?
Issue 5:	How should the cost to reduce deferred maintenance be estimated?
Issue 6:	How can the consequences of unfunded maintenance be estimated and reported? If so, how?
Issue 7:	Is there a need for predicting future deteriorations/failure? How can it be done?
Issue 8:	How should deferred maintenance needs be prioritized? Should estimates of the costs to bring deferred maintenance up to acceptable conditions be grouped into categories reflecting degrees of importance?
Issue 9:	What requirements should be established as to common assumptions and ground-rules across agencies that prepare deferred maintenance estimates?
Issue 10:	To what extent should information about the uncertainties in the deferred maintenance estimates be calculated and reported?
Issue 11:	What liability or other legal issues can arise?
Issue 12:	When and where should deferred maintenance be reported?
Issue 13:	How should large maintenance backlogs be handled and reported?
Issue 14:	What are the basic analytical steps needed to estimate and report on deferred maintenance?

Issue 1: What is the relevance and importance of deferred maintenance?

A number of interrelated reasons for addressing deferred maintenance issues more systematically were identified in the materials and agencies examined. The central reason appears to be to call attention to the amount of infrastructure that is deficient because maintenance has been deferred -- so that explicit attention to it is provided by operating agencies, the chief executive officer, elected officials, and the public. The Government Accounting Standards Board (GASB 1993) emphasized the need for the executive branch to communicate to elected officials and the public. This is to encourage public officials to correct deficiencies and to gain support from the public for correcting the deficiencies Advisory Commission on Intergovernmental Relations (ACIR 1993). Public officials in the federal and other governments often mistakenly assume that operating budgets are sufficient to provide proper maintenance.1

The Federal Accounting Standards Advisory Board (FASAB) stated that "Managers of government facilities need to know the facilities' condition and estimate future outlays made necessary by deferring needed maintenance" (1993). Grant and Lemer (1993) stated that "most federal programs emphasize new construction and fail to confront maintenance issues". Currie (1987) and Van Daniker and Kwiatkowski (1986) are others who explicitly called for reporting deferred maintenance, but without discussing the reasons. Currie, however, stated that management's primary accountability for assets is to maintain them in good and consistent condition. Therefore, information for management is required that responds to this accountability. This point, however, does not specifically address the need for reporting deferred maintenance.

The Office of Management and Budget (OMB) (Bulletin 93-02) requires reporting of "unfunded liabilities" for federal agencies, but at present this does not appear to cover deferred maintenance but only such clearly legal requirements as pension and accrued leave obligations. At the local government level, issuance of revenue bonds can require, under bond covenants, assessments of the adequacy of maintenance and repair programs. New York City's Transit Authority and Water Authority, are both required under such covenants to have "reasonable amounts" for maintenance. For example, bonds to rebuild the subway trackbed require the trackbed "to be maintained" (Regan 1989).

Behind all of the above appears to be the fundamental concern that the existence of deferred maintenance implies that the quality and/or reliability of service provided by infrastructure on which maintenance has been deferred is lower than it should be, and thus the infrastructure is not or will not later be adequately serving the public.

Recommendation: Reporting on deferred maintenance (and its service quality and health and safety implications) seems likely both to provide valuable information to those responsible for resource allocation and planning and to encourage attention to important maintenance needs. Public agencies should provide estimates of the extent of deferred maintenance and the implications of the deferrals.

Issue 2: How should "deferred maintenance" be defined?

The literature does not contain a consensus on how to define deferred maintenance. However, those who attempt (explicitly or implicitly) a definition use some version of "the repairs needed to restore an asset to its normal operating capacity and life expectancy." Van Daniker and Kwiatkowski (1986, pp. 116 & 117) used the definition "to restore an asset to its full operating capacity" in their mail survey

questionnaire. However, based on responses they received to this survey, they suggested that the words "full operating capacity" be changed to "normal operating capacity." They also suggested that the appropriate measure of deferred maintenance be the "estimated current cost of eliminating the deferred maintenance".

An ACIR Task Force on Maintenance (1993) recommended that "the cost of needed maintenance should be estimated by.....calculating the cost to return assets to an acceptable condition based on established standards."

Patten and Wambgnass (1991) defined deferred capital maintenance as "......the estimated charge for maintenance and rehabilitation costs needed to keep fixed assets operational that are put off or deferred to a future period." They also felt that deferred maintenance measures the ability to keep assets operational and avoids shifting the burden to the future.

The term "deferred maintenance" is not universally used for the concept. Such terms as "unfunded maintenance," "backlog," and "unaccomplished maintenance" also are used. These terms appear to be used interchangeably; none of the literature we reviewed identified differences in the terms. The 1993 ACIR report used the term "unfunded maintenance" rather than "deferred maintenance," but the terms "unfunded maintenance" and "deferred maintenance" appeared to be equivalent. San Jose used both "unfunded maintenance needs" and "backlog cost". These costs were calculated by subtracting the amount of work actually funded from the amount of work that should be done (San Jose, February 1993), thus producing what appears to be the cost to correct the deferred maintenance. The U.S. Army Corps of Engineers has been using the word "backlog" in its effort to develop a uniform backlog reporting system.

A reasonable consensus seems to exist that the definition of deferred maintenance should not cover work needed for growth, enhancements, or increases in capacity (Currie 1987; Patten 1991; AASHTO 1993; and Connecticut 1993). Inevitably, problems can arise in deciding whether needed corrections fall into the enhancement category or the renewal category. For example, what about modernization of public housing such as updating its plumbing? Into which category does this fall? What about removal of lead paint or asbestos? What about "obsolete" equipment? Will groundrules be needed that identify under what conditions "modernization/obsolescence" should be considered deferred maintenance rather than as enhancements?

A consensus also appears to exist that the word "maintenance" in the term deferred maintenance should encompass both repairs that would be funded out of capital budgets (used by state and local governments) as well as repairs funded from operating budgets. The analogy in the federal government is the separation of appropriations into "construction" and "operations and maintenance." Major rehabilitation and replacement costs over a certain level can usually be funded out of construction appropriations.

Some members of the accounting community have used the term "renewals accounting" in part to distinguish deferred maintenance from the concept of depreciation. Currie (1987), for example, defined renewals accounting as "measuring the current cost of consumption if renewals programs are up-to-date and the systems are in a steady state." This definition appears to be equivalent to that of providing deferred maintenance information, i.e., the cost of the work required to keep infrastructure in acceptable condition or in legal compliance. However, this definition appears to include not only maintenance that has been deferred, but also the maintenance expenditures budgeted for the year.

Recommendation: In summary, a rough consensus appears to exist that the dollar figure that should be reported (e.g., annually) is "the estimated cost to return assets to an acceptable condition."

Issue 3: The need for condition assessments: Is sufficient condition assessment information available?

Little question seems to exist that to make estimates of deferred maintenance a government needs to assess the condition of its individual assets. This implies that the government should have a reasonably accurate inventory of assets. Considerable work has been done on condition assessment procedures. Most large agencies have some systematic approach to making such estimates. Regular condition assessment is almost universal for bridges and highly prevalent for pavements.

The condition assessments for other systems are less developed, such as for buildings and underground piping systems. Underground assets, particularly, present major problems for government. Guglomo et al. (1992/3); O'Day et al. (1986) for the American Water Works Research Foundation; The Urban Institute (1984); San Jose (1993), and CH2MHILL (1992) all describe condition assessment techniques for underground pipe systems. A dilemma, however, is that the cost of underground condition assessment procedures can be excessive if an agency attempts to cover all its underground assets, such as inspecting all pipe sections. These condition assessment procedures, therefore, are likely to involve statistical samples of the full population of pipe sections.

This procedure can be refined to focus on pipe sections that are at greatest risk based on inventory information about the pipe section's material, age, soil conditions, load information, etc. (For example, old cast iron pipe will have a much higher likelihood of problems than ductile iron, and locations with frequent road and utility cuts are likely to have significantly more problems). Information from statistical samples can give estimates of the prevalence of pipe sections that warrant attention (e.g., are below acceptable performance levels). However, the remaining dilemma is that statistical samples will not indicate which specific sections not in the sample need immediate attention. Thus, while the agency can estimate the cost to repair pipe sections that are below acceptable condition levels, the agency will not know which particular sections are currently in poor condition and should soon be repaired. The cost of finding those specific sections is an additional cost that can be prohibitive.

This special problem with underground infrastructure highlights the issue as to whether reporting of deferred maintenance, and the costs to correct it, need to be handled differently than for above-ground infrastructure.

Recommendation: Each public agency that is responsible for significant amount of infrastructure should have a systematic process for regularly assessing the condition of that infrastructure. This is needed even if the agency does not analyze and report on deferred maintenance.

Issue 4: <u>**How should benchmarks/standards be established for acceptable condition levels?**</u>

Establishing benchmarks for each type of asset is a step that is needed to establish the extent of deferred maintenance. Only assets whose condition is below the "acceptable" condition level should be included as deferred maintenance. (An exception to this does exist: deferring purely preventive maintenance.)

This issue is explicitly, or implicitly, identified as important in the literature that addresses the details of establishing specific deferred maintenance levels (Grant and Lemer 1993; Currie 1987; GASB 1993; O'Day, et al., 1986), and the literature on maintenance analysis activities Connecticut (1988); Dallas (1982); New York City (1993); and San Jose (1993). If a road segment, pipe segment or a building component is performing at some adequate level, even though not perfectly, presumably maintenance and repair (other than preventive maintenance) are not currently needed.

The State of Connecticut established a benchmark as to what would be an "acceptable level" of pavement condition and, for bridges, a "good or better" condition level. Dallas did not identify its standards, but apparently left its determination to judgments by agency personnel. New York City estimated the cost to restore assets to "a state of good repair", primarily for buildings, roads, and bridges. San Jose selected as the department's objective that sewers will operate at a service level defined as "unrestricted sewer flow". For pavements, the agency used an overall condition rating. The agency identified an optimal maintenance strategy in which pavement sections would be sealed at the point that the segment deteriorated to what it labeled as a "fair" condition based on the pavement condition rating. (The options the agency considered but did not recommend included allowing the pavement to deteriorate to greater degrees.)

Connecticut (for roads), New York City (for roads and, less so, for buildings), and San Jose (for sewer pipes and roads) have used a <u>systematic</u> procedure for condition assessment and established measurable standards to use as the "acceptable" condition.

An important aspect of this issue is who sets these standards. For the most part, the standards used in the four government examples were established by agency professionals, based on whatever condition assessment procedures were used by those agencies. In no instances, did we find the standards based, even in part, on customer input. Inevitably, the decisions as to what condition levels are used to establish minimum-acceptable condition levels is a judgment call -- but one that can be based on information and professional standards or judgments regarding factors such as safety and effects on service quality.

The Corps of Engineers' contractor for its examination of backlog reporting systems favored asking programs to report on multiple services levels, such as "minimal acceptable," "normal condition," and "optimal condition" (Management Analysis, Inc. 1993). The contractor noted that this would provide more information but requires more effort to calculate the backlog for each level. The contractor also suggested use of performance standards as a more objective target but recognized that these are often not available. A road pavement condition index presumably would be such a standard, but a subjective judgment is still required to determine what index value should be used as the standard.

In the above examples, none of these procedures appear to have used information from <u>outside the operating agency</u> to establish the standard, though the New York City process was directed by the city's Office of Management and Budget. GASB (1993) states that acceptable standards should be established by

one's own community and noted that different communities might have different standards of acceptability. The U.S. Department of Energy System for the condition of buildings aggregates national industry consensus standards for both inspection methods and deficiency standards. The cost to correct these deficiencies (i.e., bring the item back to industry standard condition) is then calculated based on those national standards. It is interesting to note that none of the materials reviewed suggested obtaining input from elected officials or the general public as to service quality standards.

ACIR (1993) suggested that a government might want to calculate and report on more than one level of service. Estimates might be presented, for example, for different serviceability levels, such as "minimally acceptable" and "fully acceptable". This implies that the agency would need to establish multiple benchmarks/standards. There is also support for using interim and long-term goals for maintenance of assets, which would provide a scale and perspective against which decision-makers can track progress.

Recommendation: Public agencies should have standards for their various types of infrastructure, preferably based, at least in part, on service performance (not only on technical characteristics). Such standards might be developed in part using user (customer) input, at least on the service performance elements. Agencies should consider establishing two levels of serviceability, such as a "minimum" level and a more desirable level.

Issue 5: How should the cost to reduce deferred maintenance be estimated?

Most materials we reviewed assumed that the amount of deferred maintenance that would be reported would be the cost to bring the existing level up to the pre-specified acceptable condition level. Proposed budgets could identify both the estimated cost of correcting maintenance at the time the budget year began and also at the end of that budget year, taking into account the deterioration likely to occur in the budget year and the maintenance funding provided in the proposed budget. That is, the cost to correct deferred maintenance includes the cost to correct deferred maintenance expected during the current year, plus the added cost for repairing assets already below the acceptable condition but which deteriorated even further during the year.

Few agencies are likely to have the resources to make "engineering" cost estimates for all asset with deferred maintenance. The estimates, thus, usually would need to assume the type of repair and, as most maintenance management systems do, use average unit-cost figures for each type of repair to make the estimates. Such average unit-costs were used in the New York City, Connecticut, and San Jose.

Cost analysis is complicated when an agency has multiple options for bringing a defective asset to an acceptable condition, and those options can significantly affect the cost to make the repair. For example, different depths of road overlays can be used, or the road can be reconstructed. Only patching might be done to make the road rideable for short periods of times. Similarly, sewer pipes can be patched, lined, or replaced. For buildings and other structures, while some failed components may need to be replaced without a wide range of cost options, in most situations the agency will have major options as to the degree of repair, including complete replacement.

Thus, a question for reporting deferred maintenance is whether such estimates should represent the minimum cost to bring assets up to the acceptable level of service for that year or should represent the costs required to undertake the optimal replacement policy. For example, a pavement might be repaired at low cost by merely patching. This cost would represent the minimum cost. An optimal repair policy, however, might call for resurfacing the road, thus costing much more in the budget year, but over the long-run it would provide a higher level of service for a lower long-run cost. Which number should be included as the deferred maintenance dollar estimate? Should one or the other, or both, be estimated and reported? In most situations, the optimal cost option would yield a higher current cost for correcting the deferred maintenance; however, for some situations the reverse could occur. For example, it is conceivable that the optimal solution might be to defer any maintenance on a piece of road and let it deteriorate to a somewhat lower condition, knowing it was below the acceptable service level. The asset would be delivering service below the acceptable level, but from an optimal cost view-point; this continued deferral might be preferable for that particular asset. Which cost figures should be included for the agency's estimate of deferred maintenance: figures that cover just bringing the assets up to minimum acceptable levels or the costs believed to be the optimum, and possibly much higher, costs? Or should both cost levels be calculated and reported?

With the advent of maintenance management systems for many, if not most, major infrastructure items, the current trend of these systems is to focus on estimating optimal solutions. See, for example, AASHTO (1993); Gifford et al. (1993); and San Jose (1993). These systems do not generally make explicit estimates of the cost of correcting deferred maintenance up to a minimum level, though most of these systems seem likely to have this capability.

Recommendation: It is probably best to provide both "minimum" and "optimum" estimates of the cost to correct deferred maintenance. This will give decision makers reasonable options that they can relate to the tightness of the coming budget year.

Issue 6: Can the consequences of unfunded maintenance be estimated and reported? If so, how?

Simply knowing how much deferred maintenance exists is not likely, by itself, to mean much to agency managers, elected officials, or the public. Information as to the consequences of the deferrals seems vital to getting appropriate attention to the deferrals. Information on the consequences of deferring maintenance is needed to asses the "deferability" of the maintenance projects.

We found two basic types of information on deferral consequences: (1) increased future costs to the government of making later repairs due to increased deterioration; and (2) programmatic consequences such as poor ride quality, backed-up sewers, damage from leaking roofs, reduced safety of the users of the assets, etc. In our examination, we were not able to find many agencies that regularly generated systematically-collected data on either type of information. Such steps seem uncommon. Agencies appear to rely more on general qualitative, subjective statements (oral and written) than on usually hard-to-develop data.

Our interviews indicate that public officials, such as elected officials and chief administrative officers find the most convincing and compelling information to be the future costs that can be avoided by undertaking early, preventive or corrective maintenance activities. The officials with whom we spoke did not identify lack of information on non-financial impacts as being a prime omission. This may, however,

be due at least in part to the fact that most such information they usually receive on non-financial impacts has been primarily highly qualitative and subjective, providing little clear supportable evidence. These officials recognize that service problems such as projections of incidents and impacts of rough roads, sewer backups, and leaky roofs are important, but they do not appear to feel they can obtain such information even if they wanted it.

Consensus appears to exist that one of the major consequences/benefits of reducing or eliminating deferred maintenance is to reduce future maintenance, repair, and rehabilitation costs (cost avoidance).

Credibility of the information is a major concern of these public officials. One official indicated to us that he would like to receive data on cost avoidance that was confirmed by some form of audit or at least by an independent office that reviewed the data and certified it to be reasonably accurate. The feeling is that agency personnel have a self interest in increasing their budgets and (might) tend not to be as critical of the data as they should.

Some of the materials reviewed emphasized the need to report information on the service implications of the deferred maintenance, such as GASB (1993); O'Day and Neumann (1984); Pallot (1990); and ACIR (1993). AASHTO (1993) indicated the need to estimate the "costs," that is the disbenefits, of deferred maintenance. Simon and Jodrey (1993) expressed the need for bureaus of the U.S. Department of the Interior to identify the service impacts of proposed budget requests, presumably covering the correction of deferred maintenance needs in order to save travel time or reduce accidents.

Both the cities of Dallas and San Jose provided general statements for particular items as to the likely impact of the deficient infrastructure items. For example, in discussing its need for correcting deferred maintenance of traffic signs, Dallas pointed out their degrading visibility and, thus, reduced user convenience and safety. San Jose, in discussing pavement needs, noted the additional cost to users because of road defects and estimated the additional user costs depending on how far below standard the actual pavement was. (As noted earlier, however, San Jose's sewer management system predicts the percentage of pipe that is likely to be at various specific condition levels.)

A set of hazard-level rating categories for the Corps of Engineers for its flood control projects is shown in Exhibit 6-1 (Management Analysis, Inc. 1993). These are applied to dam-failure risk, with each project rated as to whether it falls into one of three hazard-potential categories (low, significant, or high) based on technical judgments on both the potential for loss of life and for economic loss. Such sets of categories could be established for other types of infrastructure.

The assumption in reporting such information is that it would likely influence elected officials and the public, generating interest in reducing the deferred maintenance. However, this effect would depend on such factors as the specific nature of the information, its credibility, and whether the identified service deficiency levels appeared large enough to warrant correction when compared to other agency needs and budget priorities.

Exhibit 6-1: Hazard Potential Classification

Category	Loss of Life (Extent of Development)	Economic Loss (Extent of Development)
Low	None expected (No permanent structures for human habitation)	Minimal (Undeveloped to occasional structures or agriculture)
Significant	Few (No urban development and no more than a small number of inhabitable structures)	Appreciable (Notable agriculture, industry, or structures)
High	More than a few	Excessive (Extensive community, industry, or agriculture)

A concern not explicitly addressed in the materials reviewed is the difficulty of estimating specific impacts. General statements are much easier to make. For example, a Navy inspection survey calls for inspectors to report "specific mission impact" such as: "frequent failure of the taxiway lighting directly impedes mission capability of the facility to conduct night flight operations." (Management Analysis, Inc. 1993) While such assertions provide some information, they are not likely to be as convincing or to carry as much weight as those suggested by data based on historical evidence that estimates the actual extent to which the deferred maintenance is reducing service levels.

Recommendation: Ideally, agencies should provide estimates of both the added costs and service impacts due to deferrals. The state-of-the-art is quite weak, however, for making such estimates, especially service impacts. Agencies should, however, make a try at estimating added future costs and provide at least qualitative estimates about the likely service impacts of deferrals.

Issue 7: Is there a need for predicting future deteriorations/failure? How can it be done?

Predicting future deterioration/failure rates appears to have three primary uses: (1) for estimating future, out-year budget needs; (2) for determining the optimal repair/replacement cycles for particular types of infrastructure; and (3) for estimating the amount of cost that is likely to be avoided if maintenance is done sooner. These are interrelated purposes, but for this report, the focus is on the third use, estimating cost avoided (that is, the extra cost incurred if maintenance is deferred). The importance of this use has been discussed under Issue 6.

Systematic procedures for making these predictions require considerable effort to develop and are not currently in wide use in the United States. Maintenance management systems for road pavements, however, usually include such estimates and are an exception.

Maintenance management systems, which are becoming increasingly popular, usually include priority-setting procedures that include deterioration/failure predictions as a major element. Deterioration rates of the assets are estimated in order to develop optimal replacement strategies that indicate when repairs should be done and at what cost. For example, the PAVER road maintenance system of the Corps of

Engineers and American Public Works Association contains a pavement deterioration model. Users are instructed how to input data on their own pavement-life histories to generate their own deterioration curves, for various types of road materials and road types. (APWA estimates that about 135 local and state governments are currently using PAVER, as well as some state aviation agencies and some federal installations, especially defense installations.)

Estimating deferred maintenance for a particular budget year, however, presumably requires only the estimation of deterioration for the budget year in order to project the deferred maintenance at the end of the budget year given the maintenance budget proposed for that budget year. Dallas, New York City, and San Jose also provide estimates of the backlog of deferred maintenance for future years.

Guglomo, et. al. (1992/3); San Jose (1993), and O'Day, et. al. (1986) indicate that predictive systems for the condition of pipe sections are also available. For example, the GPIPER system for steel gas pipes predicts the first year of leak based on historical information on other pipe. San Jose's Sewer Management System contains curves calculated to relate pipe condition to age for pipes made of various materials and as related to pipe rehabilitation strategy. These predictions, however, are not used explicitly to estimate cost avoidance as part of annual reporting on deferred-maintenance.

The Corps of Engineers' is attempting through its emerging BUILDER system to include deterioration curves for major building components, but at present these are not available.

On the whole, it is safe to say that the state-of-the-art in predicting deterioration/failure rates for infrastructure is not well developed. It is farthest advanced for road pavements as compared to water and sewer pipe and building components. Such predictions are best applied today for situations where they are used to provide aggregated data. They are not likely to be as reliable for predicting the future life of individual assets, especially assets such as pipes and building components.

Recommendation: Predicting deterioration/failure rates is very difficult; only in roads (and perhaps bridges) does much work to develop such prediction capability appear to have been done. It will likely take a national effort to improve the state-of-the-art.

Issue 8: How should deferred maintenance needs be prioritized? Should estimates of the costs to bring deferred maintenance up to acceptable conditions be grouped into categories reflecting degrees of importance?

Aggregating the costs to bring all deferred maintenance up to acceptable condition, whether for the whole agency or for the whole government, can produce huge numbers. Agency and headquarters officials will likely want not only the overall number, but also breakouts by type of asset and an indication of the degree of importance of the defective units.

ACIR (1993) pointed out that deferred maintenance might be split into categories that represent different priority/importance levels, such as "high-priority" (or "critical") vs. "low-priority," based on each asset's usage and risk-safety-impact potential.

The condition level does not necessarily alone establish its priority, i.e., level of importance, for repair. For example, some road pavements rated worse than others might have lower importance to a jurisdiction than other, more travelled roads that had a better condition rating.

The State of Connecticut (1988) pointed out that lowering the acceptable condition level would lower the estimate of needed repair cost. O'Day and Neumann (1984) expressed considerable concern that over-reliance on "design standards" with an excessive margin of safety would result in excessive estimates on maintenance needs. They felt that it was necessary to balance the ability to improve many items against having more stringent standards that would permit those standards to be applied to only a relatively few items.

The Department of Energy has recently introduced a system for rating each project using a variety of criteria such as health and safety, compliance with directives, and environmental considerations. (This process is described in more detail under Issue 15.)

DOE developed a risk-based prioritization rating process for its facilities to help it rank priorities for early funding. This rating procedure is then applied to its buildings, its other structures and utilities, and its major equipment. It rates each item on four major categories: health and safety, environment, safeguards and security, and programmatic. Each of these categories is further subdivided into a number of subcategories. Exhibits 8-1 and 8-2, respectively, show the "major category" and "subcategory" scoring and rating criteria. (The subcategory exhibit is DOE's "programmatic" subcategory.) Generally, these ratings are based on judgments; fully objective criteria are seldom available for most of the rated characteristics. The inspectors doing the condition assessments for each facility can provide ratings if they wish. In any case, program personnel at each higher level review the ratings to determine the priority of projects to be funded. Projects are then compared across the Department (e.g., among the Department's facilities).

New York City reports its costs to bring assets to a "state of good repair" in four priority categories: A, B, C, & D. These ratings are technical judgments made by the agency based on "relative importance to the structural integrity of the asset." Priority categories are based on the importance of the defective components to the whole building or systems, when failure is expected, and the extent and severity of observed deficiencies. (New York City Executive Summary 1994).

San Jose's sewer management system includes a process for weighting the condition level (expressed as the number of points for observed corrosion and structural problems) by factors that rated the potential "impact," based on location, amount of traffic, and pipe size (the latter is used as an indicator of how much of the jurisdiction is served by the pipeline).

Recommendation: Each agency should at least categorize its deferred maintenance into two or three categories of importance/criticality. This will make the deferred maintenance information considerably more useful to decision makers. Information as to future cost and service implications, as discussed under Issue 6, should be used in this categorization.

Exhibit 8-1: Category/Subcategory Benchmark Criteria

Major Category Rating Criteria				
Score	I. Health & Safety	II. Environment	III. Safeguard & Security	IV. Programmatic
10	Acceptable risk; minor incidents unlikely	In compliance; working towards ALARA	Minor problems unlikely	Minor problems unlikely
20	Minor incidents slightly likely	Consistently in compliance; violations extremely unlikely	Routinely secure with acceptable risk	Adequate with acceptable risk
30	Minor incidents moderately likely; serious incidents unlikely	Routinely in compliance; low-impact violations are the exception; no off-site concern	Routinely secure with some minor problems	Adequate with some minor problems
40	Minor incidents moderately likely; serious incidents slightly likely	Occasional violations of moderate consequence	Modest threat to classified information, technology, and parts (moderately likely)	Adequacy in question with many minor problems
50	Minor incidents likely; serious incidents moderately likely	Frequent problems of moderate consequence; occasional serious problems; moderate off-site concern	Serious threat to classified information, technology, property, and parts (moderate likely)	Mission accomplishment at moderate risk
60	Serious incidents likely; fatalities unlikely	Consistently have problems of moderate consequence; frequent serious problems	Serious threat to SNM/tritium or personnel (moderately likely)	Mission accomplishment at high risk
70	Serious incidents highly likely; fatalities moderately likely	Highly likely large and uncontrolled contamination/release to off-site areas with lasting serious environmental impact	Extreme threat to SNM or personnel (moderate likely); extreme threat to classified information, technology, property, and parts (highly likely)	Critical/strategic mission accomplishment severely impacted or shut down
80	Highly likely life-threatening situation		Extreme threat to SNM or personnel (highly likely)	

Exhibit 8-2: Category/Subcategory Benchmark Criteria

	Programmatic Rating Criteria						
Score	**Compliance with Orders, Initiatives, and Directives**	**Best Management Practice**	**Technological Base (R&D)**	**Capability**	**Capacity**	**Quality**	**Physical Condition**
10	Exceeds requirements	No concerns		State of the art to meet known future requirements	Exceeds requirements; minor improvements possible	Able to meet requirements; minor improvements possible	Like-new condition
20	In compliance, but upcoming problems slightly likely	No intervention at present, but upcoming action possible; IROR $\geq$ 20%	Develop new technology in support of mission and national objective; long-term probability of success and/or high risk	Process adequate to meet program mission requirements, but improvements warranted	Viable for mission	Able to meet requirements; minor improvements possible	Good - performs to original specs with routine preventive maintenance; downtime does not affect operation/mission
30	Consistently in compliance, with occasional minor deviations	Some minor concerns/ recommendations; IROR $\geq$ 50%	Develop new approaches, techniques, and methodologies to improve operations			Able to meet requirements; some significant improvements required	Adequate - meets mission, but cannot perform to all original specs, some corrective maintenance necessary
40		IROR $\geq$ 75%; Some significant concerns/ recommendations	Develop new methodologies to improve/enhance mission capability and efficiency; intermediate probability of success and/or medium risk	Can meet mission with problems likely	Viable for mission on schedule with overtime; problems moderately likely	Able to meet requirements; many significant improvements required	Fair - Occasional substandard operations; repetitive corrective maintenance; can meet mission with minor problems
50	Frequently in compliance, but serious violations occasionally occur	Violation of internal standards; suspension of operations daily; IROR $\geq$ 100%	Develop new methodologies to improve/enhance mission capability and efficiency; short-term probability of success and/or low risk	Can meet mission with difficulty	On schedule with significant overtime	Unable to meet some requirements	Poor - consistent substandard performance; operations/mission threatened
60	Serious violations frequent, or many continuing minor deviations; shutdown possible	Mandated fixes and schedules due to significant problems; likely suspension of operations pending action	Develop necessary methodologies, processes, and techniques in support of critical programmatic objectives; short-term probability of success and/or low risk	Cannot meet mission; or unique capability in jeopardy	Inadequate capacity to support minimum requirements of mission	Unable to meet most requirements	Severely deteriorated; mission assignment at high risk
70				Critical/strategic mission capability does not exist			Critical/strategic facilities inoperable

Issue 9: **<u>What requirements should be established to common assumptions and ground-rules across agencies that prepare deferred maintenance estimates?</u>**

Governments appear to want to combine maintenance needs estimates across departments in addition to reporting them for each department. New York City, for example, presents annual city-wide estimates of "State of Good Repair Needs," as well as for each of its departments.

Simon and Jodrey (1993), in describing the U.S. Department of Interior's maintenance needs estimates, indicated that it was important to have different bureaus, and different programs within bureaus work with common assumptions and ground-rules when preparing budget requests, presumably relating to deferred maintenance estimates. This is needed, they indicate, so that better choices can be made and so that estimates from different offices are comparable. The particular examples used in their paper were that estimates should "use similar assumptions about the estimating period, assumptions about economic growth, the same definitions of activities or facilities, treatment of O&M expenses, etc." (The article does not further clarify these items.)

This same point was emphasized to us by both the U.S. Department of Energy and the Corps of Engineers. It is highly desirable to have compatible procedures for estimating maintenance needs and deferred maintenance across their districts and facilities.

A report for the Corps of Engineers' emerging Uniform Maintenance Backlog Reporting System (Management Analysis, Inc. 1993) presses for commonality across the Corps as to:

- definition of backlog, including the scope of projects to be included (for example, one project manager might consider overdue preventive maintenance to be covered; others might not; some managers might not count major replacement projects, believing that these are not included under the term "maintenance", etc.)
- Consistency in reporting maintenance needs with similar "levels of rigor" (For example, one manager might identify a lengthy list of backlog items; others might not even bother to identify them due to low expectation of receiving funds for such items.)
- Consistency in costing.
- Consistency in prioritizing projects.

The Corps' condition rating procedures for hydropower equipment, for example, uses a standard "condition index scale" for each type of equipment, whether electrical, mechanical, or structural -- see Exhibit 9-1 for the scale used to rate all such equipment (U.S. Army Corps of Engineers, Hydroelectric Design Center 1993). To achieve this commonality, the Corps has accepted the use of generalized verbal rating categories, as shown in the exhibit. The Corps uses the same scale for a variety of civil works facilities and equipment. This permits the Corps to compare more reliably the condition of different facilities and equipment.

Estimates of future economic and demographic conditions that affect the loads on assets (such as pavements, water systems, and building usage) can affect deterioration rates, though probably only modestly over the next budget year. Use of the same projected data are likely to be more important for deferred maintenance estimates for years beyond the budget year.

Exhibit 9-1: Condition Index Scale		
Value	Condition Description	
85-100	Excellent	No noticeable defects. Some aging or wear may be noticeable.
70-84	Very Good	Only minor deterioration or defects are evident.
55-69	Good	Some deterioration or defects are evident, but function is not significantly affected.
40-54	Fair	Moderate deterioration. Function is still adequate.
25-39	Poor	Serious deterioration in at least some portions of equipment. Function is inadequate.
10-24	Very poor	Extensive deterioration. Barely functional.
0-9	Failed	No longer functions. General failure or failure of a major component.

Recommendation: A government, and each of its agencies, should provide at least general guidance as to the definition of "deferred maintenance," such as the condition level to which deficient assets would be raised when estimating the cost of deferred maintenance. That is, the groundrules (and definitions of terms) for all agencies should specify whether the level should be the "minimal acceptable" level or some higher condition level. Inevitably, agencies with different types of assets and different condition assessment procedures will have latitude in interpreting the standard in their own way, but at least the government should seek a reasonable degree of comparability. Periodically, the government (and each agency for its own component organizations) should review the interpretations used throughout its agency(ies) to ensure that reasonable interpretations have been used.

Issue 10: To what extent should information about the uncertainties in the deferred maintenance estimates be calculated and reported?

ACIR (1993, p. 32) suggested that agencies "should identify and include in their maintenance-need reports, the extent of uncertainty in the estimates used by them in making their major maintenance decisions". The report goes on to note that predicting the future is inherently uncertain, such as estimates of future usage and service lives, but that it is better to use professional judgments to estimate the magnitude of these elements than not to consider such information.

The uncertainties refer to estimated unit-cost for repairs, the impacts on service levels due to not making these repairs, and, to some extent, the asset condition estimates (in cases where the condition assessment procedures are at least partly judgmental or based on statistical data, such as when sampling underground pipe sections).

None of the other materials we reviewed, including the materials from the governments we examined, included estimates of uncertainties. Thus, none of the materials we examined indicated how such reporting of uncertainty would be done, how feasible it would be, or how useful these estimates would be.

Obviously, making estimates of the amount of uncertainty is difficult. Most of the cost, condition assessment, and deterioration rate projections usually are not based on statistical descriptive data and do not lend themselves to estimates of statistical uncertainty.

Recommendation: When estimates are likely to be highly uncertain, agencies should indicate this to users of the information. At least engineering-type, best judgment, estimates should be made, such as the ranges for key estimates of cost and service implications.

Issue 11: What liability or other legal issues can arise?

Regan (1989) pointed out that when revenue bonds are used to pay for capital assets, the bond arrangements may include legal mandates to "maintain the assets," that is, prevent premature deterioration of the assets purchased from the revenue. In New York City both the transit and water authorities have these mandates on assets procured using funds from revenue bonds. However, Regan does not address the issue of what happens if the local government is not able to fully fund the maintenance required.

A legal issue not covered in the literature we reviewed, but one that has been raised on occasion, is potential liability from infrastructure that has been labeled as defective by the condition assessment process, but which has not been repaired and for which some users incur harm because of its defects. Does the formal reporting of deficiencies put the government into excessive risk of legal damage liability? This question arises, however, whether or not the government reports on deferred maintenance; it applies to any situation in which an agency does infrastructure condition assessments and reports specific items considered to be defective. Could citizens, for example, succeed in a lawsuit based on excessive road problems -- receiving damage costs relating to their vehicle use on those roads? Is this an issue for deferred maintenance?

The government officials we interviewed were usually not worried about legal problems arising from the reporting of aggregated data on amount of deferred maintenance. They all noted that the government would be in legal trouble if an inspector found a hazardous condition but did not report it, or it was reported but the government did not make a reasonable effort to correct the hazard. This, they agreed, does not affect reporting the amount of deferred maintenance. Legal issues can arise whenever an agency does condition assessments, regardless of whether or not the agency reports on maintenance deferrals.

Recommendations: Agencies need to be reasonably certain that their condition assessment and deferred maintenance processes are handled in a legally-defensible manner. Most potential legal problems, however, seem related to condition assessment, and not to deferred maintenance reporting.

Issue 12: When and where should deferred maintenance be reported?

A consensus appears to be present that deferred maintenance should be reported annually -- by each operating agency and by the government as a whole. It is less clear from the existing literature where it should be reported. GASB (1993) suggested that the dollar amount be reported in either a separate section of the financial report or as a separate report. Van Daniker and Kwiatkowski (1986) indicated that it should be included in financial reports. Pallot (1990), writing for an Australian audience, suggested that the dollar

shortfall should be reported in "Statements of Commitments," a financial report, and that service shortfalls should be presented in a separate "Statement of Performance." Patten and Wambgnass (1991) suggested that the data be presented as a "contra-account in a balance sheet" offsetting the amount of the organization's investment in their fixed assets. However, they appear to be thinking in terms of private-sector balance sheets, not generally used in public organizations (other than by special service districts). Regan (1989) emphasized the need to report to the public (to discourage the prevailing pattern of neglect of maintenance) but did not explicitly identify where the information should be reported.

None of the literature explicitly called for reporting this information as part of budget submissions. However, clearly the reports are intended to affect future budget decisions. San Jose provides an annual status report to the City Council on unfunded maintenance. New York City provides a special report covering such information to its City Council as required under the City Charter. The City of Dallas in its special issue paper on deferred maintenance (1982) proposed that the City Council provide a special deferred maintenance budget.

OMB (Circular 93-02) calls for reporting "unfunded liabilities" as part of an agency's annual financial statement, but as noted earlier, deferred maintenance does not appear at present to be included as an unfunded liability.

New York City, San Jose, and the Department of Energy all appear to provide their estimates as part of separate reports, but the findings from these reports are linked to their budget submissions.

Public agencies currently seldom appear to provide defensible information to elected officials (or to the public) as to the implications of deferring maintenance for the assets managed by those agencies. This makes it difficult for elected officials to justify maintenance expenditures in times of scarce resources.

Recommendation: Estimates of deferred maintenance, and its implications should be included in the budget process so that maintenance deferrals are adequately considered. More controversial is whether deferred maintenance should be reported in annual agency and government reports. In the interest of full disclosure, such reporting also appears best.

Issue 13: How should large maintenance backlogs be handled and reported?

The Connecticut, Dallas, New York City, and San Jose reports all identified deferred maintenance backlogs that their reports indicated could not be corrected in one year. Because backlogs were too large to be corrected in one year, they provided multi-year estimates of amounts needed to reduce, and eventually eliminate, the total deferred maintenance. Thus, these governments presented both an estimate of the total amount of deferred maintenance and a plan for eliminating that backlog over time.

As New York City pointed out in its 1993 asset condition report, it may not be possible in one year to plan, design, and implement the work needed to catch-up completely. The work is likely to need to be spread out over a number of years. Interim and long-term goals could be established to provide benchmarks or performance measures that lead to elimination of all or much of the accumulated maintenance backlogs.

Recommendations: As done by the cities and state cited above, for large backlogs, agencies should not only report the total backlog but also provide practical multi-year plans to phase-out at least the more critical deferred maintenance.

Issue 14: What are the basic analytical steps needed to estimate and report on deferred maintenance?

The following basic analytical steps appear to apply to the analysis and reporting of deferred or unfunded maintenance for any public service and any category of infrastructure.

1. Estimation of the current condition of the public assets, such as the percentage of facility components in various degrees of condition.

2. Determination of a minimal acceptable condition level for each type of asset.

3. Estimation of the cost required to bring those infrastructure items that are in less than acceptable condition up to the acceptable condition level.

4. Estimation, in as quantitative a way as possible, of the implications of deferring maintenance, both (a) the dollar cost that would be avoided in the future, if any, by undertaking the above maintenance; and (b) the "programmatic consequences" (e.g., the negative effects) that would be avoided in the future if the infrastructure below acceptable conditions are brought up to an acceptable level.

The rationale for these four steps has been discussed, respectively, under Issues 3-6.

We found three additional and related analytical steps included in some of the new maintenance management system models: (1) selection of the optimal (usually least cost) maintenance/repair/ rehabilitation procedure for each item, considering such factors as life-cycle costs and the future value of money; (2) procedures to prioritize projects, considering such factors as total costs, readiness to undertake the projects, and importance of the project to program needs; and (3) projections of maintenance needs several years into the future.

The first additional step, identifying the optimal maintenance approach, is likely in most cases to provide higher cost estimates for the near future (but not over the long-run) for needed maintenance than merely estimating the cost needed to bring the items to a minimum acceptable condition. This is so, since in considering what is best done to account for "life-cycle" needs, larger early investments may provide greater savings than merely "patching" the current condition. As discussed under Issue 5, deciding which set of costs to use is up to each agency itself -- the use of minimal costs or optimal costs (or both) when providing estimates of unfunded maintenance can be at the discretion of the agency. The models used in New York City, San Jose, and the Department of Energy all sought to identify the optimal approach.

The second additional step, project prioritization (included in the Department of Energy's process and the San Jose sewer management system), is needed when the funds likely to be available are not sufficient to meet all the maintenance needs, i.e., when unfunded, deferred maintenance is expected to be non-zero. This step, while highly useful, is not essential for the more limited purpose of merely reporting

the gross amount of current unfunded, deferred maintenance. However, this information could be very useful in reporting size of deferred maintenance by priority category (e.g., "high", "medium", and "low), as discussed under Issue 8.

The third additional step, projecting maintenance needs for future years, could be useful for identifying future unfunded maintenance given various assumptions as to the future deterioration of assets and the amount that will be funded each year for maintenance work.

The four basic analytical steps, possibly along with the three additional analyses, seem worthwhile. The downside is the cost and effort required. The first basic step, condition assessment, thus far, appears to be the most costly step. It is also the step in most widespread use. Setting minimum acceptable condition levels (Step 2) is not likely to be expensive, but it can be quite difficult to do. Estimating costs to correct deficiencies (Step 3) appears to be relatively easy, except when the agency attempts to consider life-cycle costs and the optimum maintenance option. (San Jose has been using its models to develop optimum, low cost maintenance approaches. New York City and the Department of Energy appear to use the latest engineering cost estimates based on various cost factors for the assumed maintenance strategy; they are not attempting to identify optimum maintenance approaches, at least not as part of these procedures.) Estimating the future implications of deferring maintenance (Step 4) is the most difficult. It requires knowledge that can be quite difficult to obtain, such as future deterioration rates and future service effects of deferring maintenance.

<u>Recommendation:</u> Public agencies should have a systematic process for regularly (annually) estimating the amount, and implications, of its deferred maintenance. The four analytical steps should be applied, recognizing often severe state-of-the-art limitations in making these estimates -- thus, requiring, some reliance on expert judgment. Where expert judgment is needed, such as in estimating future service implications, a reasonably formal process for obtaining those judgments is desirable.

Differences In Types of Infrastructure When Analyzing Deferred Maintenance

Estimates of deferred maintenance will inevitably originate within each particular government agency. Agencies differ considerably as to the types of infrastructure they maintained. Even within any one agency, different types of infrastructure usually exist.

There will be major differences among types of infrastructure in undertaking the five basic analytical steps listed in Issue 14. In actual practice, making these estimates can be quite difficult. The extent of difficulty differs considerably among different types of infrastructure. To illustrate this concern, below we discuss these problems for three major types of infrastructure: roads, water and sewer systems, and buildings.

Roads

The analysis of roads is considerably further advanced than most other infrastructure categories, such as water and sewer lines, and buildings. Substantial problems still exist, however.

Condition Assessment. State and local agencies have been using a variety of road condition assessment techniques for many years. The federal government has supported considerable developmental work. It also uses these techniques in many of its facilities that contain roads, such as defense installations.

A substantial variety of condition assessment procedures for road pavements has been used throughout the United States at all levels of government. Detailed discussion of these various techniques is beyond the scope of this report.

Many governments have used such measurements as the "Present Serviceability Rating" (PSR); some have used the "Pavement Serviceability Index" (PSI). Both assess road roughness. The PSR often uses a roughness meter towed from a vehicle to provide an objective measure of pavement roughness. In addition, beginning in 1990, all states were required to report the "International Roughness Index (IRI)" to the Federal Highway Administration for selected portions of the National Highway Network (Hyman, et al. 1993). Exhibit 15-1 presents the "pavement serviceability rating" categories developed by the Federal Highway Administration.

The field distinguishes "distress measures" from "roughness measures." Many states and some localities gather not only pavement roughness information but also pavement distress data. The latter provides more details concerning pavement deterioration by identifying specific types of distress, including various forms of cracking.

The PAVER system developed by the Construction Engineering Research Laboratory of the Army Corps of Engineers and disseminated by the American Public Works Association includes in its software model various pavement condition ratings, including a variety of pavement distress and roughness indicators (Johnson (undated); Shahin and Walther 1990).

Thus, the state-of-the-art of condition assessment for roads appears quite good. For example, San Jose assigns to pavements an "overall condition number (OCN)" based on ride quality, weathering, drainage, surface condition, and measured stress. It groups the numerical values for the OCNs into six categories, excellent, good, fair, poor, very poor, and failed. It also divides pavement segments by whether the segment is a major arterial, minor arterial, major collector, neighborhood, or alleyway.

The condition assessment process is labor intensive. Particularly for pavement distress, it requires inspectors to observe the roadbed closely when making their ratings. The road roughness measurements, using some form of road meter, requires a vehicle, metering equipment, and a crew to drive along roads at pre-specified speeds to obtain the data. While these are costly procedures, nevertheless, many governments at all levels are undertaking such condition assessments.

Most jurisdictions do not inspect all their roads annually; this often is neither feasible nor necessary. For the purposes of estimating deferred maintenance, the focus can be on the network of roads considered in aggregate or, at least, in major groupings such as by categories of road material and road use. San Jose, for example, inspects one-third of its major streets and one-fifth of the minor streets each year.

The fact that the condition of road pavements is directly observable by citizens who use the roads means that public officials cannot easily ignore poor conditions. As will be seen, the less visible underground sewer and water pipe systems, and only partially visible, buildings have not received as much condition assessment attention as road pavements.

Exhibit 15-1: Pavement Serviceability Rating for Highways

Pavement Condition Rating (Use full range of values)	
PSR & Verbal Rating	Description
5.0	
Very Good	Only new (or nearly new) pavements are likely to be smooth enough and sufficiently free of cracks and patches to qualify for this category. All pavements constructed or resurfaced during the data year would normally be rated very good.
4.0	
Good	Pavements in this category, although not quite as smooth as those described above, give a first class ride and exhibit few, if any, visible signs of surface deterioration. Flexible pavements may be beginning to show evidence of rutting and fine random cracks. Rigid pavements may be beginning to show evidence of slight surface deterioration, such as minor cracks and spalling
3.0	
Fair	The riding qualities of pavements in this category are noticeably inferior to those of new pavements, and may be barely tolerable for high speed traffic. Surface defects of flexible pavements may include rutting, map cracking, and extensive patching. Rigid pavements in this group may have a few joint failures, faulting and cracking, and some pumping.
2.0	
Poor	Pavements that have deteriorated to such an extent that they affect the speed of free-flow traffic. Flexible pavements have large potholes and deep cracks. Distress includes ravelling, cracking, rutting, and occurs over 50 percent or more of the surface. Rigid pavement distress includes joint spalling, faulting, patching, cracking, scaling, and may include pumping and faulting.
1.0	
Very Poor	Pavements that are in an extremely deteriorated condition. The facility is passable only at reduced speeds, and with considerable ride discomfort. Large potholes and deep cracks exist. Distress occurs over 75 percent or more of the surface.
0.0	

Source: Federal Highway Administration, *Highway Performance Monitoring System Field Manual* (Washington, DC, December 1987), Table IV-4.

Establishing Minimum-Acceptable Condition Levels. Given the good state-of-the-art of condition assessment, it is not surprising to find that on occasion, acceptable levels have been specified using the systematically collected data.

For example, the Connecticut State Department of Transportation in its 1987-1988 examination of local roads used a modification of a pavement condition rating procedure developed by the State of New York (which included the use of photographs and narrative ratings to help inspectors rate the roads). Road pavements in urban and rural areas were rated on a scale of 1-10 (with 10 being the best condition). The state established a benchmark of "an acceptable level" of pavement condition, using a rating of "7" for pavements in urban areas and "6" for rural areas. The higher conditional level standard for urban areas was applied because of heavier vehicles and higher traffic volumes. The department used that data to estimate the cost to bring pavements below the acceptable level to an acceptable level. Connecticut's DOT pointed out in its report that if it had lowered the acceptable condition level, this would have lowered its estimates of needed repair costs. While it is not fully clear how the State selected its standards, it appears that it was part of a partially political process and not solely an engineering-derived number (Connecticut 1988).

It appears, however, that state, local, and federal agencies do not explicitly attempt to identify a minimum acceptable level for their road pavements, but this can be readily done, if only by using engineering judgments.

It, however, is likely to be preferable, and more relevant, to select an "acceptable level" based on systematic feedback obtained from road users. The PAVER system develops cost estimates to correct conditions, but primarily bases this on the identification of the condition level at which the pavement condition rating begins to drop rapidly on the assumption that this is the point at which major cost avoidance can be done. The trigger is not an "acceptable" condition from the viewpoint of users, but one of economics.

Estimating The Cost to Bring Assets to an Acceptable Condition. Many of the pavement management systems of state and local governments, including PAVER, utilize a variety of cost factors based on historical information about the cost of various types of road repairs. Some of these models attempt to identify the optimal replacement policy, which as indicated earlier can provide a somewhat different cost than the minimal cost needed to bring the road condition to the acceptable level. That is, the optimal decision-rule might call for delaying work until the condition had fallen below the acceptable level, or on the other hand, might call for a large scale repair that would last for a long period of time rather than a series of much smaller repairs done more frequently but which are likely to be more expensive over the long run.

Estimating Future Cost Avoidance. Of the types of infrastructure we examined, road maintenance was by far the most advanced. It was the only system that appeared to have significant empirical evidence as to the relationship between condition and age (e.g., with empirically-derived deterioration curves). The PAVER system literature notes that the ability to predict pavement deterioration is a critical element in planning and cost allocation for pavement maintenance and repair activities. PAVER initially used straight-line extrapolations of the last two pavement-condition index (PCI) points to predict future conditions. The developers felt that this method was accurate for short periods of time but not over a long period. In 1990, PAVER switched to a more sophisticated procedure using statistical techniques to fit curves to the data (PAVER 1990). PAVER calls for the development of families of deterioration curves based on pavement

sections likely to have similar deterioration characteristics, such as surface type (asphalt, concrete, brick, etc.) and category of road (e.g., arterials, collectors, residential, industrial, primary, secondary).

San Jose's pavement management system also provides deterioration curves, using them to help determine the type of work expected to be done based on the pavement condition value. For example, major roads with an overall condition number (OCN) of over 25 would be subject to reconstruction; overlays would be expected for OCNs between 18 and 20; only minor maintenance would be done for OCNs of 12-14. The maintenance alternative identified for each OCN is shown in Exhibit 15-2. This information is used to help develop an optimal strategy for road pavements in various condition levels. San Jose also distinguishes minor roads from major roads based on traffic volumes, speeds, and loads, with greater values for these requiring a higher level of service for safety reasons (San Jose 1993).

With such procedures, the future predicted condition, its associated maintenance strategy, and the estimated cost of that strategy, can be used together to estimate the added cost if the pavement maintenance is deferred rather than repaired soon.

These procedures, however, are not in general use across the nation to predict either the amount of deferred maintenance or the cost that could be avoided by funding maintenance in the near future.

Estimating Future Non-Financial Implications. Not funding road pavement maintenance usually will lead to increased ride roughness, with resulting increased wear and tear on vehicles. Rougher roads also can increase the likelihood of traffic accidents, with resulting property damage, injuries, and even deaths. Poor road conditions also slow traffic, with delay times for commercial and non-commercial traffic and potential lost "value" from added commuting time.

Most current pavement condition indices appear to contain a road-quality component. Therefore, these condition indices can be used as a proxy for ride quality. Some past attempts have been made to relate road roughness indicators to driver and passenger comfort by having "judges" provide ratings as to road-ride quality, and subsequently correlating these to the road condition measurement values. Such relationships, however, are seldom used. In reporting the potential consequences of deferred maintenance of road pavements, agencies can identify the expected decrease in pavement condition, and even illustrate these conditions through the use of photographic (or video) examples of different pavement conditions, so that public officials and the public can get a sense of the value of improving road conditions.

As to implications for safety, travel time, and the like, some work has been done to estimate linkages with road condition (and considerable empirical data could probably be readily available for making such analyses in the future). However, for the most part, estimates of the relationship between pavement condition and traffic accidents, or travel time, are seldom made. These might have to be tailored to particular local conditions even if national figures became available.

Water and Sewer Systems

Condition Assessment. Water and sewer distribution systems are primarily underground. Even those small proportions of sewer pipes above ground have their internal area hidden from easy view. Thus, inspections of the condition of pipe can be expensive.

Exhibit 15-2: Required Maintenance for OCN

MINOR ROAD

OCN	ACTIVITY
0-11	Non-Scheduled Maint. Wit until OCN=12
12-14	Chip Seal
15-19	Non-Scheduled Maint. Wait until OCN=20
20-22	Resurface
23-24	Non-Scheduled Maint. Wait until OCN=25
25+	Reconstruct

MAJOR ROAD

OCN	ACTIVITY
0-11	Non-Scheduled Maint. Wait until OCN=12
12-14	Slurry Seal
15-19	Non-Scheduled Maint. Wait until OCN=18
18-20	Resurface
21-24	Non-Scheduled Maint. Wait until OCN=25
25+	Reconstruct

No "standard" condition rating system appears to exist for either water or sewer pipe. However, some agencies have developed procedures for their own use, sometimes through contracts with engineering firms. The major condition assessment procedures currently used for sewer pipe are TV inspection, using crews and a van that receive images remotely from a camera that passes through the pipe. For example, TV inspections in San Jose are used on 6" and larger pipe. San Jose estimates that contractors charge from $1.50 to $2.00 per foot for such inspections, though the city believes that when its crews can be used, this cost is considerably less. Even, at $1.50 per foot, inspecting one mile of pipe would cost about $8,000. A jurisdiction with a 1,000 miles of pipe would need about $8,000,000 to inspect annually all its pipe.

On the brighter side, however, it is not likely to be necessary (nor feasible) to inspect annually each mile of pipe. Statistical sampling can be used to provide representative data on the distribution of pipe conditions. Sampling will not, however, identify which specific pipe segments are defective, except for those segments in the sample. A good strategy appears to be to use a stratified statistical sample with relatively frequent inspections of those pipe segments that are at greater risk, as identified by such factors as material, age, size, location (including soil conditions, traffic above the pipe, and frequency of utility cuts), and past history of problems.

Agencies also use TV inspections to examine pipe for which complaints are received and other problems that arise throughout the year. San Jose's sewer management system includes an extensive set of guidelines for assigning points to various defects found in the inspections. Inspectors code the observed conditions onto standardized inspection forms. The computer assigns points to each defect and sums them to calculate a total defect score for each pipe section (San Jose 1993). These inspections are made more reliable through use of an inspection manual that provides photographic examples of various defects.

Establishing Minimum-Acceptable Condition Levels. Establishing minimum-acceptable condition levels for water and sewer pipe is difficult and has seldom been done. San Jose, however, as part of the sewer management system, has grouped pipe defect scores into five categories (A, B, C, D, and F) as shown in Exhibit 15-3 (CH2MHILL 1992). These categories also identify the estimated type of maintenance activity at each condition level. The process specifies that significant repair becomes needed for a rating of "D". This, in effect, could be called San Jose's minimum acceptable level, although that term is not used.

Except for breaks requiring immediate attention, pipes continue to function to some extent even if badly corroded or leaking. But these defects eventually reduce water pressure, cause the loss of valuable water, release sewerage into soil and water, cause backups in basements, and so on. But at the time the condition is observed, these may not have actually yet occurred. Thus, for water and sewer pipe, "minimum-acceptable condition" might more appropriately be labelled something like "minimum-acceptable risk condition."

The determination that a pipe segment is below acceptable level is usually primarily an engineering judgment. In addition, other factors will affect that judgment, factors relating to the importance of the particular pipe segment. For example, the San Jose sewer management system model calculates an "impact factor" based on pipe location (residential, industrial, or commercial), traffic (light, medium, or heavy), and pipe size (with larger pipe assumed to have larger impact).

The Seattle Water Department has used a rating system for its large water-pipe projects that includes both pipe condition elements and estimated impacts. Exhibit 15-4 shows the rating form that was used by

Seattle (The Urban Institute 1984). Such elements as the "visual inspection" findings and "percentage of pitting" could be used as a basis for establishing acceptable condition levels.

Procedures such as these could be used by an agency to establish cut-off ratings that could be used to determine how much pipe repair work should be labelled as deferred maintenance if not covered by existing budgets. Inevitably, however, such cut-off points will be somewhat arbitrary. Different cut-off points could be used for pipe with different criticality ratings; the latter could, in the Seattle water main example, be derived from the other elements shown in Exhibit 15-4.

Estimating the Costs to Bring Assets to an Acceptable Condition. If the agency knows the amount of pipe that is in less than acceptable condition, estimating the cost to repair does not appear to pose a major problem. For example, San Jose has begun using basic cost factors and algorithms to select the likely low-cost option and to develop maintenance cost estimates based on the distribution of sewer pipe conditions found by its inspections. Agencies are likely to be able to develop cost factors for various types of repairs from their own historical experience.

More difficult is the step of estimating how many of each type of repair would be needed to bring the pipe system up to an acceptable condition. Emerging sewer management systems, such as those of San Jose, could be used to estimate optimal maintenance procedures. The procedures need to consider the various maintenance options that agencies have. Relatively inexpensive options include cleaning, point repair, and grouting. More expensive options (required as pipe condition worsens) include various types of lining and replacement.

Estimating Future Cost Avoidance. A major problem in estimating cost avoidance if maintenance is done in the near future is that the deterioration rates for water and sewer pipes are not currently known. Little work appears to have been done to estimate future deterioration and break expectancies for pipe of various materials, sizes, soil conditions, etc. When such information becomes available, it will make estimating the amount of cost avoidance feasible. Currently, however, water and sewer agencies may not be able to make reasonably accurate estimates of the amount of future costs that would be avoided if repairs to defective pipe are soon made, at least not for the jurisdiction's complete water or sewer system.

Estimating Future Non-Financial Implications. Other implications of not taking adequate current care of water and sewer pipes include: constricting sewer flow and ultimately leading to backups into homes; water main breaks that disrupt traffic and cause disruption and damage; breaks in sewer pipes causing odors and wastes entering ground and surface waters leading to complaints and environmental problems; loss of valuable water from water main leaks; and reduced water pressure at homes, buildings, and fire hydrants. Estimating the frequency, and damage, caused by such occurrences is difficult. Expert judgments might be used by an agency to provide, at least rough, qualitative estimates of the likely consequences of deferring maintenance.

Summary comments. A major problem in justifying maintenance for underground systems is that until actual problems occur, the agency will not know which pipe segments are actually defective, except for those segments that have been inspected that year. For example, a statistically representative survey of sewer pipe might indicate that 10% was in poor structural or corrosive condition but, except for the segments included in the sample, would not identify which particular segment. The cost of inspections to identify all problem pipes could be quite high.

Exhibit 15-3: City of San Jose Sewer Management System Predictive Model Ratings		
Condition Category	**Description**	**Rating Range**
A	Pipe in sound condition; perform routine inspection and cleaning	0-134
B	Pipe generally sound; should be inspected within several years	135-562
C	Point repairs should be made to extend life and reduce likelihood of programs	563-2,355
D	Point repairs necessary to maintain service in structurally damaged pipes; corroded pipes require inspection. Line replacement should be considered.	2,356-9,867
F	Replace or rehabilitate pipe in order to maintain service.	>9,867

Exhibit 15-4: City of Seattle: Criteria for Rating Large Water-Pipe Projects

1. **Visual Inspection**
   0. Excellent lining
   2. Good lining, no repairs needed
   4. Good lining, slight repairs needed
   6. Fair lining, some ruse, beyond corrective maintenance
   8. Loose lining, much rusting and pitting
   10. No lining, much rusting and pitting

2. **Necessity of the Water Main for Area Supply**
   0. Not needed
   1. Long-term shutdown anytime
   2. Long-term shutdown except peak draw or special conditions
   3. Short-term shutdown anytime
   4. Essential during peak draw
   5. Essential all the time

3. **Effect on Water Quality**
   0. No effect
   2. Slight corrosion causing coloration
   4. Loose lining
   6. Loose lining and slight corrosion
   8. Extreme corrosion with no loose lining
   10. Extreme corrosion and much loose lining

4. **Percentage of Steel Thickness Removed at Internal Pits**
   0. No putting
   2. Surface corrosion only
   4. 25%
   6. 50%
   8. 75%
   10. 100% (holes from inside corrosion)

5. **History of Leaks over Past Ten Years**
   0. No leaks
   1. 1 to 3 leaks per 10,000 feet
   2. 4 or 5 leaks per 10,000 feet
   3. 6 or 7 leaks per 10,000 feet
   4. 8 or 9 leaks per 10,000 feet
   5. 10 or more leaks per 10,000 feet

SOURCE: Seattle Water Department, "Steel Pipe Internal Inspection Report"

If the defective pipe segments sampled are found to be concentrated in pipe of a particular material and age (as is likely), and the agency has reliable inventory data on pipe materials and age, the agency can use a strategy of inspecting these at-risk pipe segments to determine if early repairs are warranted. Estimates of maintenance needs and deferred maintenance might then focus primarily on these segments of high-risk known defective segments. Such a focused inspection process could also concentrate on areas of the community with large loadings, such as commercial areas, corrosive loadings, and heavy traffic and poor soil conditions.

With the current state-of-the-art available for inspections, water and sewer agencies are likely to have difficulties in obtaining estimates of the condition of their network of pipes. Minimum acceptable condition levels have not generally been established for pipe conditions, though rating systems are available (such as that used in San Jose). It is even more difficult to estimate the cost avoidance from early corrective action and to estimate the non-financial problems that would be avoided by not deferring maintenance.

For both sewer and water mains, strategies should be used such as replacement of all pipe that is old or made of at-risk materials, or is located in at-risk locations, or is likely to be costly and face the possibility that much of the replaced pipe could have lasted for many years without severe problems leading to major premature replacement cost.

Buildings

Governments have many public buildings, probably many more than the public commonly realizes. They include the basic federal, state, and local administration buildings, correctional facilities, storage and maintenance shops, courts, libraries, recreational facilities, various human service facilities, police precincts, fire stations, military facilities, various utility facilities, and so on.

<u>Condition Assessment.</u> Condition assessment of buildings through inspections is certainly feasible but is highly labor-intensive and, thus, can be costly. Buildings have many types of components including roofs, walls, HVAC (heating, ventilation, and air conditioning), electrical systems, etc. Each of these major systems can be comprised of many different components. Both New York City and the U.S. Department of Energy, for example, use three-person teams of structural, mechanical, and electrical inspectors to inspect their buildings.

Assessing the condition of the building <u>as a whole</u> is also an issue. Building condition assessment procedures primarily have focused on components rather than the overall building (such as those of the Department of Energy, New York City, San Jose, and the Corps of Engineers' BUILDER model). Overall ratings for each facility, however, can be developed by combining component deficiency data (such as is done in San Jose).

<u>Establishing "Minimum-Acceptable" Condition Levels.</u> This is difficult for buildings. Persons that work in buildings and outside visitors will be concerned about various comfort, safety, convenience, and appearance features. Many public buildings also have major programmatic functions, such as laboratories, correctional facilities, and libraries. Both sets of considerations are likely to be important in establishing acceptable condition levels.

Building inspectors identify problems with components that need repair. But component conditions can be defective but still not be causing major problems for building users. Does the problem level warrant

early correction? Clearly, the importance of a defect depends to a considerable extent on the defect's effects on health, safety, and the mission of the program that the infrastructure supports. U.S. Department of Energy Offices emphasized this point to us, noting that a "minor" roof leak for some of its facilities would be a minor issue, but if the leak was in one of its laboratories, it could be a major problem. Some types of defects in a building with many public visitors are likely to command more attention from the agency because of their visibility.

The minimum-acceptable level of the defect, therefore, needs to be considered in the context of the building's mission. If vital to the mission, repairs can normally be expected to be accomplished soon and not fall into the category of deferred maintenance. However, when funds are scarce (the usual case), repair costs if large are likely to face questions of priority, and might be deferred, depending on the perceived importance of the mission supported by that building (including political considerations).

Thus, different standards for "minimum acceptable" physical condition for building components are likely to be appropriate and to depend on mission effects. Importance of the particular asset (based, for example, on who uses the facility and what it is used for), and the risks involved, will need to be part of the determination of minimum-acceptable condition.

In addition to establishing different minimum standards for the same type of building, depending on mission, agencies might also want to calculate and report deferred maintenance for a higher standard than only the minimum-acceptable condition level -- as a second option for public officials who decide the level of funds to be allocated to infrastructure maintenance.

Complete failures of components that are quickly noticeable to occupants, such as breakdowns of air conditioning, heating, elevators, and lighting, will be quickly noticed and corrected. However, partial breakdowns can occur. At what level do these become "unacceptable"? Clearly, occupants can (and do) tolerate some degree of building problems (but with increasing annoyances as these build up), and these problems will have different degrees of safety and health risks.

For other building components, (such as roofs, walls, and mechanical and electrical elements not noticeable to occupants) the question of what is minimally acceptable is not likely to be clear, and as discussed above, will often depend in large part on the building's "mission". Some components serve relatively minor purposes; even if they failed completely, they might be tolerated for many years.

Estimating Costs to Bring Assets to an Acceptable Condition. Estimates of the costs to bring defective building components up to an acceptable level do not appear to be a major problem once acceptable levels have been established. The Department of Energy uses the detailed, annually updated, cost factors (from R.S. Means Company) and believes these are quite accurate (especially since building contractors use the estimates in determining their prices). Such cost data are used for all DOE facilities, providing reasonable standardization of cost estimates.

The major cost analysis problem is that of identifying the lowest-cost repair option to repair a component, especially where alternative repair options are available and the cost of these differ substantially. Consideration of life-cycle costs is desirable and can affect repair choices, e.g., high initial-cost repair might be more than offset by future lower maintenance costs. As discussed under Issue 5, however, a conservative deferred maintenance estimate for the current year might be based on the low-cost option rather than a high-initial cost option that is preferable over the long run.

Estimating Future Cost Avoidance. As discussed under Issue 6, substantial evidence as to the amount of future costs that can be avoided by repairing defective components or by doing preventive maintenance is desired by elected officials.

We have not found available building component deterioration curves. Neither the Department of Energy, New York City, nor San Jose had them. They were not providing cost-avoidance information on buildings, at least not on any regular, methodical basis. Good information does not seem to be available as to what will happen to components if they are not repaired soon, e.g., how fast a small leak in a roof will develop into a much larger, and much more costly to repair, leak.

The Corps of Engineers' BUILDER project has not yet developed such relationships. Its Construction Engineering Research Laboratory's recent report includes the conceptual relationships for building components shown in Exhibit 15-5 between condition and time and the relation between condition and cost-to-repair (CERL 1993). Unfortunately, at the present time, curves based on actual data are not available.

Estimating future non-financial implications. The problem of generating information on the non-financial implications of not providing building maintenance is a major one. As discussed above, the implications are likely to be affected greatly by a building's mission.

For all buildings, defects can show up as added discomfort levels and safety-health risks for occupants, both for government employees and visitors. Building occupants and users will quickly express complaints about observable defective components. Some building problems will add risk to their health and safety. For some public buildings, service missions can be severely compromised by certain defects. For example, federal laboratories can be damaged, and the security of federal, state, and local correctional facilities can be compromised. Leaks can ruin books in libraries and damage important records kept by federal, state, or local facilities. These problems, in turn, can lead to such consequences as delays in service delivery, high non-infrastructure costs, and public safety problems. Some, but not all, major defects are likely to be corrected soon and not be part of deferred maintenance. Quick correction is not likely to occur after defects become blatant and major mission trouble begins.

The problem for deferred maintenance in buildings arises with latent defects, ones that are identified by the inspectors in their early stages and pose an uncertain later risk. Credible information on likely deterioration of these components is needed to identify the risk.

However, as with water and sewer pipe replacing components that otherwise might have taken many years to deteriorate sufficiently to cause significant problems might not be cost-effective. And in those situations when resources are likely to be available when effects on mission safety first become clearly observable and can be fixed before the defect's effects become significant, then deferring maintenance may not be a significant problem.

A risk-based rating procedure, such as that used by the Department of Energy for maintenance projects, can help identify likely effects and provide at least a rough cut at estimates of the extent of the impact of deferred maintenance. (See Exhibits 6-1 and 6-2 for examples of DOE's basic rating categories.) The Department of Energy has used this procedure for establishing repair priorities, not for estimating the implications of deferred maintenance, but the procedure appears to be adaptable to this other purpose.

'Exhibit 15-5: <u>Condition vs. Cost Curve</u>

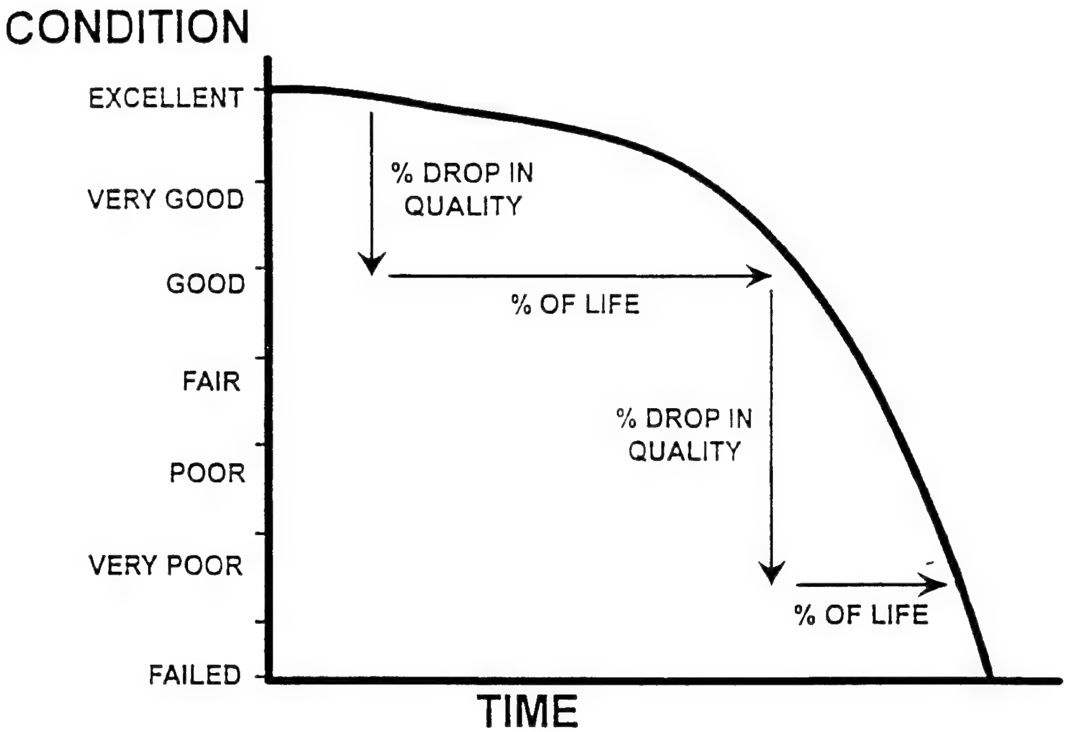
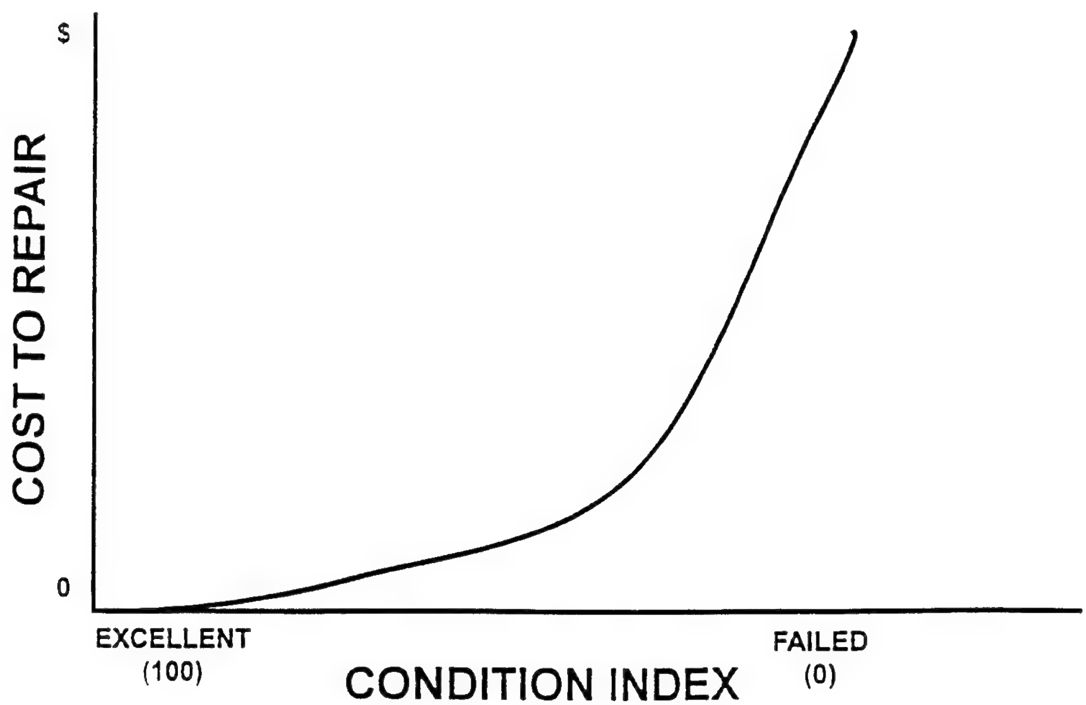


Figure 3. Deterioration Curve.



A number of local governments, such as Seattle and Milwaukee, have used procedures for rating water main projects, using such criteria as effects on water quality, essentiality of the main for area supply, and history of leaks and breaks. Other governments, such as Dayton and Denver, have used systematic priority rating procedures to help them make choices about capital projects. These consider a variety of impact criteria, such as legal requirements, health and safety, relation to policies and plans, and neighborhood impacts (The Urban Institute 1984). These procedures appear to be readily adaptable to estimating the impacts of deferred maintenance -- and, thus, provide relevant information to public officials and the public as to the extent to which funding maintenance efforts will produce important benefits.

All of these procedures for assessing non-financial impacts, thus far, appear to be based primarily on qualitative, subjective judgments, rather than on empirical data and analysis.

One additional procedure that agencies might use to obtain "impact" information on buildings is to undertake regular surveys of persons using facilities (both employees and visitors) as to their perceptions of the condition of the facilities. Such questions could be included as part of regular performance measurement procedures to track service quality, a growing activity at all three levels of government. The San Jose Department of General Services, for example, has begun to survey its facility managers on a variety of characteristics of the Department's assistance, though it has not yet included explicit questions about the condition of the facility. Ratings by users of facility conditions could be aggregated and used as indicators of the intensity of concern by users. For buildings where inspectors found significant problems, data on the frequency and severity of concerns expressed by representative samples of users would provide relevant information, systematically obtained, as to the implications of deferring maintenance, at least on those building components about which users were asked.

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LITERATURE REVIEW

OF ISSUES IN DEFERRED MAINTENANCE

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INTRODUCTION TO LITERATURE REVIEW

This report presents an annotated literature review on the topic of deferred maintenance. We do not attempt here a formal definition of "deferred maintenance." Developing a definition is one of the issues with which we hope the literature can help. However, in general, the term refers to the extent of maintenance, repair, rehabilitation, etc. that is needed to bring capital assets from a sub-par condition to needed service levels. Specific definitions of such terms as "needed service levels," and "sub-par condition" are needed to operationalize the determination of "deferred maintenance.")

Documents explicitly labeled with terms such as "deferred maintenance" or "unfunded maintenance" are extremely rare. The literature, however, contains much material on "infrastructure," including numerous works about the extent of the infrastructure problems in the United States and on specific analytical efforts, such as condition assessment procedures and optimization models for choosing optimal capital investment (often including optimal maintenance practices). While these latter materials are relevant to specialized aspects of deferred maintenance issues, we have only selectively included such items.

We include in this report those documents that we judged contained material that was closely related to the assessment and reporting of deferred maintenance even if deferred maintenance was not explicitly discussed. We examined both published and unpublished materials.

The listings are presented in two sections.

Section 1: This section contains material of particular relevance to deferred maintenance issues. These we have abstracted at some length. They are grouped into three categories:

- Documents relating primarily to accounting or reporting practices;

- Documents relating to programmatic, technical aspects of estimating or reporting deferred maintenance, often focused on specific categories of infrastructure such as bridges, water and sewer systems, and buildings.

- Documents relating to the efforts of particular jurisdictions whose materials seem potentially relevant to deferred maintenance.

Section 2: This section presents a more traditional listing of items, usually with a brief one-paragraph abstract of the document's contents relevant to deferred maintenance. This material is listed alphabetically within each of the following categories:

- By infrastructure topic;
- By category of the infrastructure (buildings, transportation, power/energy, and water systems); and
- Materials relating to specific jurisdiction.

Many of the documents listed are relevant to more than one of the above categories. We have put it in the category to which we believed it to be most related.

LITERATURE REVIEWS: ACCOUNTING AND REPORTING

Currie, Brian, *"Accounting for Infrastructure Assets,"* Public Finance and Accountancy, May 8, 1987.

Currie (of Arthur Andersen & Co.) argues that typical industrial cost-accounting procedures are not appropriate when applied to many types of public sector infrastructure. He suggests what he calls "renewals accounting". "Renewals accounting at its simplest, measures the current cost of consumption if the renewal's programs are up-to-date and the systems are in a steady state." His words "steady state" appear to mean the condition of the asset that meets some defined standard of service for the asset.

He points out that depreciation accounting is not very useful for public "assets that often have little alternative use and their lives (in the sense of being taken out of service or replaced) are very long and almost impossible to quantify. He notes that "if management is keeping the maintenance and renewal process up-to-date, the cost of maintenance and renewal should equate with the cost of consumption" and that "the cost of maintaining and renewing infrastructure is a good measure of the cost of consumption..."

He believes that management needs to "devise means of determining whether the matching of renewals to the rate of consumption is being achieved, and if it is not, what remedial action is necessary and what it will cost. He notes that if there are backlogs in the renewals expenditure that it will be necessary to provide for the catch-up required (by making a charge equivalent to the unrecorded consumption).

He indicates that, for renewals accounting, judgments will be required by management in order to: (1) define the steady state standards of service, (2) monitor asset condition, (3) distinguish between expenditures on growth and expenditures on renewals. He further notes that "careful criteria are needed to distinguish renewals expenditures from expenditures on enhancements..."

The author is primarily concerned with determining what funds should be reported each year in balance sheets (such as for a quasi-public water or transportation agency). On the whole, however, the ideas noted above seem in accord with the unfunded/deferred maintenance approach of identifying current condition, relating it to the condition and service standards for that type of asset, and estimating the short fall in funding that would be needed to bring the equipment up to standard.

Governmental Accounting Standards Board, *"Financial Reporting Model -- Capital Resources Objectives and Sub-objectives"*, Norwalk, Connecticut, Draft, November 23, 1993.

The Governmental Accounting Standards Board recommends standards for financial accounting for state and local level agencies throughout the United States. This particular draft report is a early report of the Board's look at what should be done about providing information about capital assets of governmental entities. This draft will subsequently go through a number of reviews prior to its issuance to the public at large.

The draft identifies as one of the major objectives of the information on capital assets that "the information communicated should assist users in assessing: The condition of capital assets..., changes in their condition during the period, and the estimated cost, if any, to return those assets to acceptable condition. The report defines an acceptable condition as the following: "The satisfactory, physical, or service delivery status of a capital asset as established by the community being served or entity providing the service." The draft notes that different communities may have different standards of acceptability.

The draft also indicates that the information should also assist users in assessing: The future service potential of capital assets, with service potential defined as "the capacity of capital assets to be used or to provide benefits to the governmental entity or its constituents, regardless of condition."

The GASB staff indicated that of the number of items and information that they identified in this draft of being valuable to users, that this information about the condition of capital assets and the estimated cost to return them to satisfactory condition had particular potential and should be given special consideration for inclusion as elements of capital assets reporting. Its staff also identified an assessment of the future service potential, ability to provide needed services, compared to the demand for the services that can be provided, and information about maintenance and rehabilitation needed to allow capital assets to reach their expected life and provide satisfactory services compared to the amount budgeted -- as also likely to be of particular potential of value to users.

Thus, the staff indicated that they would give a high priority to information relating to reporting of deferred maintenance and the service implications as part of any efforts to report on capital assets to elected officials and the public. However, the staff also went on to indicate that while some of the information is already being obtained and used internally in some organizations that data are not being subjected to the test for verifiability necessary for financial reporting information, nor has it been extensively evaluated for ability to communicate with elected officials and the public for use in assessing accountability and making economic, social, and political decision. Therefore, the staff recommends that it is prudent to progress slowly in developing reporting standards. They also note that it would probably be advantageous to report the information in a separate section in the financial report or as a separate report.

The draft report also prepares a draft sample format of what might be a capital asset report. This format is of particular interest and a copy is attached to this report abstract.

Pallot, June, *"The Nature of Public Assets: A Response to Mautz,"* Accounting Horizons, June 1990.

June Pallot, Senior Lecturer in Accounting at Victoria University of Wellington, New Zealand, reports that the New Zealand Society of Accountants (NZSA) recommended in its "1987 Statement of Public Sector Accounting Concepts" that community assets be reported in physical, rather than financial, terms in a "Statement of Resources" and not be depreciated. Her theme is that the concept of assets used by the commercial sector should not be unthinkingly applied to circumstances that are distinctly different, such as with many public sector assets. Community assets" are, in general, provided without generating net positive cash inflows; are of direct use to the community at large; and are not, in general, saleable, either because there is no market or because management is prevented in the community interest from selling them. She also notes that questions of inter-generational equity could arise if rates, taxes or user charges were to be based on recovery of all costs including depreciation.

She indicated that NZSA is proposing a "renewals accounting" approach similar to that identified by Brian Currie (discussed earlier). NZSA has proposed "the actual level and standard of service achieved be reported in the Statement of Service Performance while any difference between the intended level and the current level, and the expected cost of achieving the target level, be reported in the Statement of Commitments. NZSA also suggests that renewals costs "be reported in the Cost of Services Statement while actual cash outlay would be captured in the Statement of Cash Flows."

The author specifically refers to Currie's renewals accounting approach, reporting that it entails: defining steady state objectives ("the capacity level and standard of service required in a mature system of network assets"); an appraisal of asset condition "to determine what level of capital and renewals work is required to meet the steady state objectives"; and an infrastructure management plan that would "enable reporting whether renewals were up-to-date and set a provision for, catch-up, should there be a backlog."

Patten, Dennis M. and Wambsganss, Jacob R., *"Accounting for Fixed Assets in a Nonprofit Environment: A Recommendation,"* Government Accountants JOURNAL, Fall, 1991.

The authors argue that reporting "deferred capital maintenance" is much more desirable and useful for the uses of nonprofit financial reports than use of depreciation for capital assets in nonprofit organizations. (The authors are Assistant Professors of Accounting at Illinois State University and Emporia State University, respectively.)

They define deferred capital maintenance as "....the estimated charge for maintenance and rehabilitation cost needed to keep fixed assets operational that are put off or deferred to a future period."

They review both the Federal Accounting Standards Board (FASB) and the Governmental Accounting Standards Board (GASB) positions regarding depreciation reporting for not-for-profit organizations. They state that "some measure that enables users of nonprofit financial reports to assess whether these assets will continue to allow the organization to provide services into the future is justified." They also note that FASB (in its Concepts Statement #4, "Objectives and Financial Reporting by Non-Business Organizations" 1978) states that financial reporting should provide information that helps users make rational economic decisions about the allocation of resources, helps assess the ability of the organization to continue to provide their services, and helps assess how mangers have "discharged their stewardship".

The authors go on to say that deferred capital maintenance "identifies to users of nonprofit financial reports the extent to which necessary expenditures are being put off to future periods". "A focus of the financial reporting system, therefore, should be on allowing users to identify the extent to which interperiod equity is maintained," so that the current generation of citizens should not be able to shift the burden of paying for current year services to future year taxpayers (per GASB Concepts Statement #1 "Objectives of Financial Reporting," Stamford, Conn. 1987).

The authors suggest that the deferred capital maintenance amount be reported as a "contra account" in a balance sheet, offsetting the amount of the organization's investment in general fixed assets. That is, the total investment less the amount of deferred capital maintenance should be used to represent the net available amount of assets.

Regan, Edward V., ***"Holding Government Officials Accountable for Infrastructure Maintenance,"*** **Proceedings of the Academy of Political Science, vol. 37. iss. 3, 1989, pp. 180-186.**

While this item is about New York City's experience, the statements are of sufficient interest to all locations that we have included it in this Accounting and Reporting section. The author was the New York State's Comptroller. He addresses the need for accountability and reporting of infrastructure maintenance and the passage in November, 1988 of a New York City Charter provision that requires a number of major actions by the City regarding annual maintenance. These are discussed below. These charter requirements led to the establishment of the system that is described in the New York City reports abstracted in detail under the Section on "Literature Review: Jurisdictions."

The paper points out that "maintenance activities while undeniably in the public interest tend to be regarded as having low visibility and correspondingly low political payoff." It goes on to note that if a bridge or other piece of infrastructure fails or requires major rehabilitation from lack of maintenance that taxpayers have to pay twice for it, first when it was built and second for premature rebuilding. The paper also notes that items in the expense budget for maintenance often have political difficulties in securing funding, while items financed out of the capital budget, with bond proceeds, can be spread out over many future years and are not as politically visible.

The paper emphasizes that decision-makers ought to know, based on sound evidence and rigorous analysis, what maintenance requirements are -- and what the cost of neglecting maintenance are likely to be. Such information could then be considered in the light of available resources when determining budgets. ".....As long as the public remains uninformed about the extent to which public assets are not being safe-guarded, public officials will be encouraged to continue the prevailing pattern of neglect" (page 183).

He believes that a basic question is whether the legislature should impose specific legal mandates to provide the necessary maintenance, such as requiring that budgetary appropriations for maintenance be set at levels deemed sufficient to prevent the premature deterioration of capital facilities. He notes that requirements of this kind have been applied to public authorities that issue revenue bonds. For example, the New York City Transit Authority "is required, under bond covenants, to engage an outside engineer to render an independent opinion as to the adequacy of its inspection, maintenance, and repair programs. The threshold test under the bond covenant is whether these programs are sufficient to ensure the continued operation of the transit system. Similarly, the city's Water Authority is obligated to retain an independent engineer for the purpose of certifying the reasonableness of the amounts required to operate and maintain the city's water and sewage systems. Thus, the author provides a precedence for providing fairly rigid, rigorous requirements on reporting of maintenance and unmet maintenance.

The paper describes the major specific requirements of the new charter requirements. The charter revisions require the city to inventory the capital plant, assess its condition, and develop a four-year plan setting forth the budgetary requirements for maintaining the capital plan in a "state of good repair." (The paper does not provide any definition of what "good repair" means.) The charter requires that the estimates be certified as to the reasonableness by professional engineers or architects, either in-house or independent as the city chooses. The responsibility for maintenance is left with the individual operating agencies but the City's Office of Management and Budget is designated to coordinate the city-wide effort.

The charter requires that the Mayor when submitting his executive budget has to identify the amounts provided for maintenance of the city's capital plan and explain any differences between these amounts and the level certified as being needed. The Mayor must also report on actual expenditures to the maintenance in the previous and current years and explain any variances between plan and actual expenditures (page 185).

These requirements leave the determination of the amount to be spent on maintenance in the hands of public officials but require full and timely disclosure of budgetary choices. The paper notes, however, that the new provisions do not absolutely assure that neglect of the infrastructure will not occur.

U.S. Office of Management and Budget, *"Form and Content of Agency Financial Statements"*, OMB Bulletin No. 93-02, Washington, D.C., October 22, 1992.

This bulletin to the heads of executive departments lays out the basic form of individual annual federal agency financial statements. One of the elements required in the agency's "Annual Statement of Financial Position" is a section on "Unfunded Liabilities". The Bulletin explicitly notes such unfunded liabilities as accrued leave and pensions. It also includes a line called "Other Unfunded Liabilities". This includes any other liability "where funding of the liability would not occur until a future fiscal year".

The form calls for the agency to "Identify the nature and amounts of other liabilities existing at year-end for which funding will not occur until a future period. Provide other explanatory information such as the past event or transaction giving rise to the liability, the year in which the future funding is likely to occur, the probable source of a future funding, etc." (Page 53)

Despite this provision for unfunded liabilities, it is not certain that OMB would consider deferred maintenance of federal facilities as unfunded liabilities for the purpose of these financial statements. Because deferred maintenance is not specifically identified in the Bulletin, it appears that the federal government does not currently consider deferred maintenance as such a liability, perhaps because no clear legal liability requirement exists with deferred maintenance as with pensions and accrued leave. However, the Bulletin's wording appears to leave the door open for the future for such inclusion.

Van Daniker, Relmond P. and Kwiatkowski, Vernon "*Infrastructure Assets: An Assessment of User Needs and Recommendations for Financial Reporting*," **Governmental Accounting Standards Board, Stamford, CT, 1986.**

This GASB-sponsored research report presents the findings from a 1985 mail survey of a sample of (1) academics (2) investors, (3) public managers, (4) legislators, and (5) citizens about the need for financial reporting on infrastructure assets.

The survey included some questions relating to deferred maintenance. The authors note that "although the term is frequently used, there appears to be no consensus on the definition." The definition used in the questionnaire was: "Deferred maintenance is delayed repairs and upkeep that would be required to restore an asset to its full operating capacity." The majority of respondents for each of the five groups indicated that the definition was adequate. However, one change suggested by some respondents was to substitute "normal operating capacity" for "full operating capacity." Some of the these respondents indicated that full operating capacity could be interpreted to mean similar to "a new condition." The authors felt that this last suggestion was a reasonable change that would more closely describe the actual physical condition that is maintained for infrastructure assets (Pages 39-40).

The survey asked whether deferred maintenance information should be shown ("disclosed") in financial reports. A majority of all five groups said, "yes". However, while at least 84 percent, or higher, of four of the groups said "yes," for the state and local management group, only 52 percent said "yes". The respondents of each group commented on the difficulty in measuring deferred maintenance. Some respondents felt that deferred maintenance could not be reliably measured because of a lack of standards; if there are no generally accepted standards, measurements may be subjective and of little value to financial report users. The authors noted that the management group probably was also concerned with the possible substantial cost needed to develop reliable information. (Pages 40-41).

In response to a question about the type of deferred information to be disclosed, large majorities of all the groups (76-85 percent) indicated that "current cost estimates for eliminating deferred maintenance problems" were the appropriate type of information. Other types of deferred maintenance information suggested by respondents included (1) reporting any existing plans for eliminating deferred maintenance problems; and (2) reporting the long-run costs associated with deferred maintenance. (Page 41)

The survey also asked about the preferred location in financial reports of deferred maintenance information -- whether the information should be in the Introductory section, the Financial section, or the Statistical section. Four of the five groups preferred disclosing the information in the Financial section. The legislator group was divided among the financial section, the statistical section, and "other". (Page 42) Note that the questionnaire asked about the location of the information in the financial report not about in what types of reports deferred maintenance information should be provided.

Respondents were also asked to compare the usefulness of various types of information for determining whether the governmental unit had a significant deferred maintenance problem. Respondents were asked about such information as historical cost, replacement cost, budget information, and engineering information. All categories of respondents reported that "engineering information" was the best source for this purpose. The groups felt that "financial plan information" was moderately useful. Financial plans would include long-range capital improvement programs and the like, plans that provides estimates of resources expected to be available and projects that are to be undertaken. (Pages 71 and 92)

In summary, the authors recommend that deferred maintenance be defined as "delayed repairs and upkeep that would be required to restore an asset to its normal operating capacity," and that the appropriate measure of deferred maintenance be the estimated current cost of eliminating the deferred maintenance. The authors also recommended that deferred maintenance information should be disclosed in financial reports, in either the Financial section or Statistical section, but not the Introductory section of the financial report. (Pages 116-117)

Finally, the authors reported that many of the respondents indicated a strong interest in the concept of deferred maintenance. The authors felt that "additional research on alternative measures of deferred maintenance may be fruitful." "Joint research between members of the Engineering profession and members of the accounting profession may be particularly useful in addressing various deferred maintenance issues. In addition, research on the uses of deferred maintenance information should be conducted." (Page 119)

LITERATURE REVIEWS: PROGRAMMATIC

American Association of State Highway and Transportation Officials, *"Guidelines for Bridge Management Systems"*, Washington, D.C., 1993.

This work presents what it calls "minimum" requirements appropriate for bridge management systems. Such systems are intended to assess a jurisdiction's network of bridges and identify the best mix of bridge maintenance management projects. The report notes that questions have been raised concerning how economically realistic the federal and state needs estimates have been to correct structurally deficient and functionally obsolete bridges, especially in light of the limited funds available for such work. It also makes the important distinction between maintenance/repair/rehabilitation needs that are a response to deterioration, and those aimed at improvements in the network, such as widening and strengthening bridges for increased traffic.

As with other management systems, such as pavement management systems, the basic elements proposed are: a condition assessment process (with each element expressed in terms of the nature, extent, and severity of deterioration); a "deterioration" model to estimate future deterioration; level-of-service criteria (with the ability of the model to evaluate the sensitivity of results to varying standards); procedures for estimating the costs of various corrective options (from maintenance of individual elements to full-bridge replacement); and the ability to determine the minimum-cost approach to maintenance for key elements and the entire bridge.

Together these components should enable the users to generate such information as an estimate of the needs for the bridge network and their priorities; a priority listing of the various maintenance rehab replacement projects; and estimates of the current and future costs of deferred maintenance (pages 6 & 7).

The report does not detail what is meant by "the current and future cost of deferred maintenance".

CH2MHILL, ***"Sewer Management System Condition Assessment: Users Manual,"*** **City of San Jose, California, October 1992.**

This manual was prepared for the City of San Jose as part of its new sewer management system. The first half is a user's guide to a software program and, as such, is of less interest here. The second half contains a number of technical memorandum that describe in detail the current approach to condition assessment for San Jose's sewer systems.

San Jose has undertaken a random sample of TV inspections of its sewer systems. From this, it has developed an extensive rating system that maps the condition score of each pipe section into one of five condition categories: A, B, C, D, and F. Exhibit A shows the descriptions currently being used for each category. The condition category is subsequently used to estimate the rehabilitation needed and then the cost of the rehabilitation.

The system also developed deterioration curves for each of various pipe materials (such as cast iron, ductile iron, polyvinyl chloride pipe, unlined reinforced concrete pipe, and vitrified clay pipe). The report notes that these are generalized curves based on data from pipe manufacturers, pipe material associations, and San Jose data. Actual corrosion and structural conditions are determined by a variety of factors, resulting in service life variations for individual pipe segments (page 4 of the section "Technical Memorandum 1"). Exhibit B illustrates the estimated relationship between pipe age and pipe condition and how a variety of rehabilitation procedures is expected to affect pipe condition.

The system also examined alternative rehabilitation methods, primarily grouting, sliplining, thin-wall lining, and replacement. The program uses cost factors developed for each rehabilitation method. It estimated the optimal (low-cost, long-term) replacement strategy and calculated costs to repair. The model assumes that a pipe is televised when it reaches the "C" condition category, lined at a mid-D condition, and replaced when a pipe reaches the "F" category (page 5 of the section, "Technical Memorandum 2").

Thus, this report indicates that a process has been established that can be used to select a minimum-acceptable pipe condition level and to estimate the costs to repair of pipe to bring the pipe to an acceptable condition. The deterioration curves can be used to help estimate the cost that would be avoided if the pipe is not repaired, for example, the added cost to replace a pipe that had been allowed to deteriorate from, say, a "D" to an "F" condition. Note however, that such a model does not identify the specific pipe segments that need repair, at least not unless 100% of the at-risk pipe have been inspected that year.

The procedure contains provision for updating the figures as new inspections are completed. However, without periodic, TV inspections of a random sample of sewers, actual current structural condition information will have to depend on projections from the 1992 random sample.

A separate television inspection manual for sewers inspections has also been prepared for city use. That manual contains a photographic rating scale to help inspectors provide reliable ratings for each pipe segment.

Gifford, Jonathan, Uzarski, Donald, and McNeil, Sue, ***"Infrastructure: Planning and Management"*****,** **American Society of Civil Engineers, New York City, 1993.**

This book provides the proceedings of a conference on infrastructure held June 21-23, 1993 in Denver, Colorado. It contains the written versions of 99 papers delivered at this conference on infrastructure management and planning.

We detected just one paper that used a term such as deferred or unfunded maintenance. The papers primarily focused on condition assessment (certainly a major tool in identifying the magnitude of deferred maintenance) and ways to analyze actions, particularly so as to identify optimal maintenance strategies. (This is a topic closely related to deferred maintenance, but it goes beyond the deferred maintenance issue.) The conference primarily dealt with transportation infrastructure but contains a few papers on other types of infrastructure, such as wastewater collection systems. The paragraphs below summarize three of the papers presented, the three containing material most closely related to deferred maintenance.

"**How to Get Local Public Works Agencies to Use Structured Infrastructure Management Approaches**," by Paul Sachs and Roger Smith, pages 26-30. This paper describes experiences of the Metropolitan Transportation Planning Commission, a multi-county transportation planning agency in the San Francisco Bay area. The authors report that MTC annually prepares a "Budget Options Report" for each city and county jurisdiction in its area. The report reviews historical revenue and expenditures for roads; estimates future road revenues; compares estimated revenues against the need to determined from its pavement management system (PMS); determines expected short-falls or surpluses; develops other funding level options; and discusses the impact of various funding alternatives on the health of the pavement network and future funding needs. (pp 29). MTC makes estimates of needed funding but does not appear to provide an explicit estimate of deferred maintenance.

"**The State of the Art of Bridge Management Systems**," by Dixie Wells, William Scherer, and Jose Gomez, pages 182-186. This paper states that "Two conditions combine to make the bridge problem critical: the age of the structures and practice of deferring maintenance." The paper notes that maintenance is often cut from budgets since the benefits from preventive actions are not immediately felt. Deferring bridge needs causes conditions to worsen, requiring costly repairs and results in delays to users [The authors drew this point from the September 1991 DOT Report "Status of the Nation's Highways and Bridges: Conditions and Performance."]

This paper briefly summarizes the "Pontis" Bridge Management System commissioned by the Federal Highway Administration to help find the best actions that should be taken given a set of constraints. The paper encourages the Pontis position that it is essential to consider life-cycle cost. The Pontis system is based on the use of past history to make future projections about the deterioration rates of various bridge components.

The paper, however, does not indicate any attempt to explicitly estimate or report the amount of deferred maintenance, only the investment cost likely to provide the optimal long-run bridge maintenance strategy.

"**A Pavement Management System for Port Orange,**" by Michael Pietrzyk. This paper reports on a pavement management system for this Florida city (based on a model developed by Carson City, Nevada). The paper describes its pavement condition rating system, which includes information on the extent of various key problems (such as alligator cracking, patch deterioration, etc.) and the extent of severity of each condition categorized as to whether it is slight, moderate, or severe. The Port Orange model assigns points to each road segment. It then examines a number of treatment options, each of which has an associated average unit cost and expected average life span. For example, crack ceiling was estimated as having an average cost of 11 cents and an average life of 3-years vs. 14 cents and 4-years for patching, and 44 cents for 15-years for a two-inch overlay).

The model was developed to determine the cost associated with city payment maintenance and rehabilitation needs, based on visual surveys of representative payment service distress conditions and prescribed treatments determined by the city. It has been used to assist the city to develop a two-year roadway paving program.

As with most of these other systems, this one does not explicitly estimate deferred maintenance but rather attempts to provide optimal maintenance strategies.

Grant, Albert and Lemer, Andrew, editors, ***In our Own Backyard: Principles for Effective Improvement of the Nation's Infrastructure, Building Research Board,*** **National Academy Press, Washington, D.C., 1993.**

This book was prepared by the Committee on Infrastructure of the National Research Council's Building Research Board. It reports on a series of Committee meetings and examinations of three case studies (of Boston, Cincinnati, and Phoenix, supplemented by committee meetings and deliberations).

The book points out that "Most federal programs that finance or otherwise influence infrastructure emphasize new construction and fail to confront maintenance issues" (page 56). The authors also note that "Government accounting standards lack measures of financial condition equivalent to the private corporations balance sheet. Attention to substantial public assets and consequent investment spending are episodic..." (page 28). The editors note that the Committee members were particularly interested in cases of effective measurement, monitoring, and evaluation of life-cycle performance. Issues of standard setting and performance evaluation, and the balance between the benefits and cost of monitoring assessment activities throughout the life-cycle, come into play in trying to determine the characteristics of a good infrastructure management system." (Page 39)

Despite the Committee members' interest in the topic of analyzing maintenance, the case material provided on the three cities, does not describe instances of explicit efforts, analytical or otherwise, to examine maintenance or assess the extent of deferred maintenance. The one, partial, exception to this was the Cincinnati case study. The case study noted that city staff prepared performance measures to monitor activity on the infrastructure improvement program. The city began to recognize "problems that had led to neglect of maintenance in the past. The city addressed the need for an one-time catch-up" on funding, needed to correct the consequences of past neglect, an increase in spending for ongoing operations and maintenance (page 67). However, the discussion of the Cincinnati experience did not provide any detail on what the city did to estimate, analyze, and report on the maintenance backlog. The authors identified as a general principle from the Cincinnati experience that "the importance of facility maintenance -- and the costly consequences of its neglect -- are clearly demonstrated" (page 75).

In its summary of the Boston case, the author identified the general principle that "a long-term perspective of financing maintenance and repair of major facilities is needed" (page 87).

The material indicates that the City of Cincinnati might be a useful case study for either telephone or on-site exploration into their procedures relating to their analysis and reporting of unfunded maintenance.

Guglomo, Richard, Van Blaricum, Vicki, Page, C. David and Kumar, Ashok, *"GPIPER: A Maintenance Management Tool for Underground Gas Distribution Systems"* from APWA Reporter, September 1993, pp.26-27; and "MicroGPIPER Implementation Guide" U.S. Army Corps of Engineers Construction Engineering Research Laboratory, USACERL Technical Report, FM-92/04, Champaign, Illinois, July 1992.

The U.S. Army Construction Engineering Research Lab (CERL) has developed a computerized program for estimating the corrosion status of each section of underground gas pipe and for predicting the pipe sections' year of first leak. The model predicts the average behavior that would be expected of the pipe under given conditions. The full report notes that the model covers the most common type of failure in gas piping systems: corrosion of the pipe exterior. Engineers must decide whether to continue repairing leaks as they occur, to install cathodic protection, or to replace failed pipe with new steel or plastic pipe. This model is intended to help with this decision.

For each pipe section, the program calculates a Corrosion Status Index (CSI) based on various characteristics of the pipe, such as: its diameter, pipe material, wall thickness, type of coating, whether cathodically protected, and soil chemistry data, such as its resistivity, pH factor, percent moisture content, and chloride and sulfide content. The CSI goes from 100 for a brand new pipe to 0 for a completely failed pipe. (A CSI of 30 is the condition when the first leak is expected.) Each pipe section is categorized into one of seven condition classes, from "failed" to "excellent," based on its CSI.

The model prepares a "Priority Ranking Report" that ranks the pipe sections by urgency for repair. This ranking considers the CSI and the gas pressure.

The procedure also contains an economic analysis feature that estimates the present worth of various options based upon inputted unit-cost factors for rehabilitation and replacement options. This cost analysis procedure can, for example, estimate the added cost of delaying a pipe section repair after a pipe section has begun to leak.

The procedures described here seems to be applicable to a considerable extent to underground water pipe; however, this particular version seems to be primarily applicable to steel pipe. It would need to be modified for other materials, such as cast iron pipe.

The significance of this material to deferred maintenance is that it is an example of extending the ability of an agency to examine the condition of underground pipe and to determine pipe sections for which there a relatively large risk of pipe failure, such as leaks and breaks. The cost of 100% physical inspections would be considerable and is generally not feasible with underground pipe systems. Thus, prediction models based on characteristics of pipe and soil would enable estimates to be made of the condition and potential unfunded repair cost. Note however, that this model does not provide explicit estimates of the amount of unfunded/deferred

maintenance. However, it seems likely that it could be adapted for this purpose, if it is assumed that all pipe sections that fall within specific CSI and pressure ranges should be repaired.

O'Day, D. Kelly and Neumann, Lance A., *"Assessing Infrastructure Needs: The State of the Art,"* in Perspectives on Urban Infrastructure, Royce Hanson, editor, National Academy Press, Washington, D.C., 1984

This paper was one of a number presented at a symposium sponsored by the National Research Council of the National Academy of Sciences, held in February 1983. The authors presented an extensive discussion of the problems of assessing infrastructure needs. They emphasize that needs assessments are often done as a way to gain support or publicity, for undertaking infrastructure work, but in the process may be unrealistic.

They recommend that while design standards can be useful, that there has been an over reliance on them as a yard stick for measuring needs. They suggest that "There is a critical need to re-examine current standards applicable to each public system. Questions that need to be addressed include:

- Have standards risen too fast to be realistic guides for wholesale rehabilitation of expensive existing infrastructure that has been put into place over many decades?
- Do older facilities really have to meet new facility standards?
- Have the reliability vs. risk-assumptions embedded in current standards created too great a margin of safety for a given facility in life of the system-wide rehabilitation needs?"

The authors go on to state that "the overriding issue in the debate over the appropriate level of standards is whether it is better to improve a few facilities to stringent standards or many more to lower standards."

The authors note that a key issue is what the standards imply for safety, service, and the cost-effectiveness of the entire infrastructure system (pp. 75-76).

These points appear to be directly relevant to the issue of deferred maintenance of determining what level of acceptability should be used for capital items when making a cost estimate of the amount needed to bring existing infrastructure to some reasonable level of performance.

O'Day, Weiss, Chiavari, and Blair,"*Water Main Evaluation for Rehabilitation/Replacement*", American Water Works Association Research Foundation, 1986.

This report summarizes work performed by the Philadelphia Water Department on water distribution system rehabilitation replacement planning. It describes a number of ways to assess water main conditions and to analyze condition trends. The report also discusses the coordination of condition monitoring and budgeting. The report states that "Utility Managers can evaluate the adequacy of previous budget commitments by examining the system conditions over time. Increases in repair rates, for example, indicate that past investment have not kept pace with the deterioration" (page 141).

The report also states that "Utility Managers must set condition levels which they judge to be suitable target levels. These target levels should reflect the realistic assessment of both current conditions and practical levels. The condition monitoring system should provide specific information on distribution system performance and whether utility is meeting, exceeding, or missing the target levels." The report, however, does not provide suggestions about how to set the suitable target levels, nor about how to cost out the amount by which past investments have not kept pace with deterioration.

The report provides a simple but interesting diagram that represents the linkage of the water distribution system monitoring and budget processes. That figure is attached.

Simon, Benjamin M. and Jodrey, Donald S., ***"Infrastructure Investment Decisions: Setting Facilities Repair and Rehabilitation Priorities for the Department of the Interior,"*** **Public Budgeting and Financial Management, vol. 5, number 3, 1993.**

The article, written by two members of the U.S. Department of the Interior, presses for a more systematic process for making infrastructure decisions. The authors observed that the "most pervasive problem affecting the department's infrastructure is simple, physical deterioration" (page 535). This has resulted from increasing stress on their facilities due to expanded visitation, the normal aging process, but also to less than optimal maintenance and construction expenditures.

The authors are concerned that estimates of needs are often unconstrained by budget limits and, thus, represent a wish-list as opposed to "required spending".

They also emphasized that comparability of estimates from different offices is a problem. Estimates are not developed on a comparable basis, such as estimates that "use similar assumptions about the estimating period, assumptions about economic growth, the same definitions of activities or facilities, treatment of O&M expenses, etc" (page 537). The authors are also quite concerned that needs estimates do not take into consideration costs and needs related to safety and other quality issues. They feel that current funding decisions are based on the concept of "sharing the pie" with funds used to fund a little bit of everything in every bureau without explicit regard for maximizing the department's highest priorities and policies or the project's own economic benefits and cost.

They note that the National Park Service, Bureau of Land Management, and Fish and Wildlife Service each has a maintenance, management system used to collect and track information on the condition and status of facilities managed by those bureaus. The authors believe, however, that these systems have four primary problems: (1) the quality and quantity of needed services is not considered; (2) economic efficiency and cost-effectiveness criteria is not considered; (3) comparability between potential projects has not been well established; and (4) the weights used to rank projects are subjective (page 540).

The authors would like to see a process in which projects estimate the expected improvements and benefits, such as the extent to which the proposed improvement would assist in the preservation or recovery of an endangered species, or the extent to which a road rehabilitation project will save travel time or reduce vehicle wear and tear.

They also propose that agencies develop common standards and reporting assumptions that would be used by each budget unit in making their proposals for the next year.

U.S. Advisory Commission on Intergovernmental Relations, *"High Performance Public Works: A New Federal Infrastructure Investment Strategy for America"*, SR-16, November 1993.

This report presents the findings from ACIR's series of six task forces that met between February and June of 1993 on a number of infrastructure issues. The work was sponsored by the U.S. Army Corps of Engineers' Institute for Water Resources. While several chapters relate at least indirectly to the deferred maintenance topic, the chapter on "Statement of Principles and Guidelines" of the Task Force on Improving the Maintenance of Infrastructure is of particular relevance (pages 29-34). The major principles and guidelines that the Task Force members recommended for all levels of government, included the following ones that particularly relate to deferred maintenance:

- Undertake regular assessments of the condition of the infrastructure.

- Estimate the cost of unfunded maintenance by establishing condition standards for each capital asset and calculating the cost to return assets to an "acceptable" condition based on established standards. This amount should be reported annually to public officials and the public as part of the budget and financial reporting processes.

- Since, in many cases, universal accepted standards may not exist, analyze and report unfunded maintenance on more than one condition level. That is, the report would provide estimates for different serviceability levels, such as both a "minimally acceptable" and a "fully acceptable" service condition Unfunded maintenance costs "might also be categorized by priority/importance (e.g. high priority versus lower priority, based on each asset's usage and risk/safety/impact potential)" (page 32).

- Report the consequences of unfunded maintenance, not merely its cost, e.g., in budget requests. That is, each agency should estimate the "performance implications of the unfunded maintenance, including the risks to health and safety and likely economic losses."

- Identify the extent of uncertainty in these estimates to enable decision-makers to better interpret the data.

The report suggests that this information, especially when tracked over time, can encourage public officials to explicitly consider and take appropriate actions to correct the deficiencies and to gain support from the public for the corrections.

The Task Force report does not contain specific case studies, but it did refer to efforts by New York City and the U.S. Department of Energy relating to estimating and analyzing maintenance needs.

The Urban Institute, Guides to Managing Urban Capital Series, Especially, "*Guide to Selecting Maintenance Strategies for Capital Facilities,*" Harry P. Hatry and Bruce G. Steinthal, and "*Guide to Setting Priorities for Capital Investment,*" Hatry, Harry P., Millar, Annie P., and Evans, James H., The Urban Institute Press, Washington, D.C., 1994

The first volume on maintenance strategies was based on field work with ten local governments and three special districts, focusing on transportation and water and sewer agencies. The second volume on setting priorities was based on field information from those ten local governments, plus a random sample of 25 cities with a population between 125,000 and 500,000. Neither report focuses explicitly on deferred maintenance but both describe material relevant to the analysis of deferred maintenance. While these reports are somewhat old, the material still appears reasonably relevant to present day issues.

The report on maintenance strategies provides a description of a number of local government procedures for rating road and water projects. These procedures not only address the physical condition of the assets but also consider other programmatic and local government criteria. For example, Seattle's Water Department for rating pipe projects includes not only the physical condition of the pipe (such as the quality of its lining, rusting, pitting, and extent of corrosion) but also such criteria as the effects on water quality, the essentially of the water main for area water supply, and the history of leaks over the past ten years. The Transportation Planning Division of King County, (Washington) included in its criteria for evaluating transportation projects such criteria as accident rates, effect on the environment including pollution, and effect on various categories of customers. Many of these criteria, however, were measured using subjective judgments rather than quantitative data.

Such procedures are potentially relevant to deferred maintenance; similar rating criteria could be applied to maintenance projects to provide an indication of the potential impact of deferring maintenance and, conversely, the benefits of undertaking maintenance.

The report also describes specific procedures used by both Milwaukee and Seattle to develop deterioration ("survivor") curves that relate road pavement condition to age. Seattle also estimated the cost to repair for the estimated area of roads that had deteriorated to failure, based on condition assessment information. Deterioration rates when linked to the costs of repairs at various levels of deterioration could be used to provide estimates of the potential cost avoided if early maintenance is undertaken.

The report also describes a New York City analysis of water main breaks that correlated breaks with age, pipe material, and location. The analysis found little correlation with age but found that small pipes had unusually high break rates based to a considerable extent on the pipe's location (because of bedding problems, frequent street repairs, and utility cuts). Unlined cast-iron pipe also had a particularly high break rate. Similar efforts elsewhere could help a agency focus on high-risk pipes, identifying the amount of needed maintenance relating to these, thus, cutting down inspection costs.

The study also describes the famous 1979 Utah road maintenance strategy analysis that related pavements' "present serviceability index" to time and the estimated effects of overlay frequency on serviceability over time. Such analytical information can be important in supporting maintenance recommendations by providing information on both future cost avoidance and the effects on road condition if maintenance is deferred for various lengths of time.

The second report, on setting priorities for capital investments, contains a number of examples of systems for ranking project proposals, including those of Dayton, Denver, King County (Washington), Norfolk, (VA), and St. Paul. These local government procedures included a variety of criteria by which each project was rated, such as impacts on neighborhoods, on the environment, on economic development, on legal requirements, or public health and safety, etc.

Such procedures could be used for assessing the potential impacts of deferring major maintenance projects.

Uzarski, D. R., Hunter, S. L., *"Development of the BUILDER Engineered Management System for Building Maintenance: Status and Future Direction"*, U.S. Army Corps of Engineers, Construction Engineering Research Laboratory, Interim Report FM/93-XX, August 1993.

This report provides an interim status report on USACERL's efforts begun in 1990 to develop the BUILDER software system. BUILDER is intended to develop a condition rating process for buildings. The report states that the technology is hoped to be transferred throughout the Department of Defense and to other public agencies. It notes that BUILDER is expected to require training accomplished both through CERL and/or by the American Public Works Association.

This report presents a conceptual design. It does not contain actual data or actual relationships. The report lays out a conceptual system in which major building systems, and detailed sub-systems for each, are identified. Physical condition indices would be developed for each. The design proposed uses a scale from 0 to 100, from failed to excellent (with seven levels: excellent, very good, good, fair, poor, very poor, and failed). Physical deterioration information would be gathered. Deterioration curves would be developed for each building "section" (it is not clear whether "section" is meant to be individual sub-systems, components, or whatever). The actual condition of a building as rated by inspections would be mapped against the condition index.

The rate of deterioration for the various building sections would relate condition to age. The report states "as condition worsens, required maintenance and repair cost increased dramatically (Page 16)." However, this key point for justifying current maintenance is not backed up in this report by any actual evidence. (This relationship has been extensively documented for road pavements but does not appear to have been documented yet for buildings or water sewer systems.)

The report shows generalized deterioration curves (condition versus time) and generalized "condition versus cost" curves. It also presents a general equation for relating the condition index to various component distress types, severity levels, and distress densities.

Condition assessment procedures for buildings are not new; other locations undertake building inspections, such as New York City. However, if CERL can make substantial progress in developing deterioration curves for significant building components and relate the cost-to-repair to condition level and time, this would be a major advance in the ability of governments to use cost avoidance to justify current maintenance of buildings.

LITERATURE REVIEWS: JURISDICTIONS

State of Connecticut

Connecticut: "Town Road and Bridge Study, Public Act 87-584: Report to the General Assembly," Department of Transportation, State of Connecticut, January 1988.

The 1987 Connecticut General Assembly mandated a study of local roads and bridges by the State Department of Transportation and submission of an assessment report in 1988. That study is reviewed here. The study's purposes were to determine the physical condition of town roads and bridges and to estimate the cost of repairing, reconstructing, and maintaining such roads and bridges. The examination did not look at state roads.

Roads. The State DOT worked with each town to make the ratings of roads using photographic and narrative pavement condition rating procedures developed by the State of New York, modified by Connecticut's DOT. Municipalities that participated in the effort were reimbursed. Approximately 15,000 miles of improved locally-maintained roads were covered in the study.

The State established a benchmark as to what would be an "acceptable level" of pavement condition. It was established as a rating of "7" for pavements in urban areas and "6" in rural areas (based on a scale of 1-10 with 10 being the best condition.) A higher condition level standard for urban areas was applied because of heavier vehicles and higher traffic volumes.

The department estimated the cost to raise the surveyed roads to the acceptable condition level. It broke out the cost required to raise each condition (i.e., very poor, poor, fair, and good) to the rating benchmark (defined as being "excellent"). The report pointed out that lowering the acceptable condition level would lower the estimate of needed repair costs.

To make the cost estimates, the department used generalized estimates, based on the initial pavement rating, the type of pavement, and whether urban or rural. Treatment types were identified for each combination of condition and pavement type. A unit-cost figure, the cost per two-lane mile, was estimated for each treatment type. Eight categories of treatment were identified, including: do nothing, crack/joint seal, chip-seal, three re-surfacing depths, and two reconstruction options. Four pavement types were identified: rural flexible, urban flexible, rigid, and composite. (A maintenance cost for pavement ratings of 7 and 8, both at or above the benchmark level, was included to reflect the cost of maintaining those roads in their present condition. Pavement ratings of 9 and 10 were estimated to cost nothing.)

The report points out that these average, generalized costs are not the exact treatment costs required for a particular road segment.

The report also presented an estimate of the total cost to raise the entire town road network to the acceptable condition level ($7.2 billion).

The study did not include any costs for increasing the capacity of the roads.

Bridges: The study covered the 1,215 bridges that were at least 20 feet in span length. Condition ratings for the bridges were extracted from Connecticut DOT bridge files. Bridge ratings were based on Federal criteria with condition ratings from "0" (worst) to "9" (best). These were grouped into three categories of good, fair, and poor. (Ratings of 7, 8, or 9 were defined as "good"; "poor" was defined as bridges with a condition rating of 4 or lower.)

DOT then developed estimates of the cost to improve the bridges to a "good or better" condition level ($362 million in total) and the annual cost to maintain these bridges at that level ($3 million).

The cost estimates were based on average bid prices of state construction projects, then averaged with cost estimates submitted by consulting engineers. Bridges rated in poor condition were assumed to require replacement; bridges in fair condition were assumed to require upgrading; and those in good condition were assumed to require only maintenance. (The latter cost, for maintenance, was based on the square footage of the bridge.) Replacement costs were based on existing bridge dimensions and did not include any cost to increase bridge capacity.

The attached exhibit is the pie chart provided in the report that summarizes the cost estimates for both roads and bridges.

The report identified the following reasons for the current poor condition of town roads: (a) inadequate construction techniques on the older portions of the network; (b) inconsistent maintenance policy on the whole network; (c) both primarily due to insufficient funding; and (d) increased traffic loads and other forms of stress.

It is our understanding from conversations with Connecticut DOT officials that this 1988 report had considerable success with the General Assembly in obtaining additional funds for roads and bridges.

Dallas, TX

Dallas: "Deferred Maintenance Issue Paper", Office of the City Manager, Dallas, Texas, January 13, 1982.

Recent conversations with Dallas officials recently indicate that this deferred maintenance program was ended when the city felt that the deferred maintenance problem had been cleared up--a sign of a successful effort by the city. This type of analysis has not been reinstated in recent years, even though major city financial problems have occurred.

The paper identifies deferred maintenance as an issue "Because of the past practice of deferring maintenance on certain capital assets and delaying equipment replacement, ... city is now confronted with the pressing need to provide funds to perform a significant number of projects previously deferred."

The paper provides estimates for each major category of maintenance from each city department, and in total, of what it defines as deferred maintenance. Deferred maintenance is defined in the issue paper as "unfunded budget requests for capital equipment and maintenance activities from previous years." (Note that this definition does not include any reference to any specific "acceptable condition" level of the various capital assets.)

The report proposed that the City Council approve a "Deferred Maintenance Budget" for the next fiscal year of $7.7 million, reducing the required deferred maintenance funding level over the next four years to $38.4 million ($7.7 million each year). An option that the report included was to spend $3.79 million catch-up each year for ten years. The paper points out the general benefit from such catch-up funding is that it produces "a resulting increase in service, a decrease in maintenance cost or gain in productivity." However, specific quantitative estimates of these benefits was not presented.

The report requested a Council resolution that approved the proposed next year's deferred maintenance budget, authorized a five-year timetable for eliminating the deferred maintenance backlog, and supported the objective of funding all future maintenance projects with current funds. A copy of the proposed City Council resolution is attached.

While the paper did not present explicit numerical information on estimated savings or improved service quality that would result from eliminating the deferred maintenance, the paper does present for many of its specific project recommendations generalized statements as to the problems that would be alleviated. For example:

- The requested $3 million to eliminate deferred maintenance on river levee systems would avoid pump failure or inability to operate at maximum capacity that would allow water to backup outside the levee and threaten the surrounding developed areas during periods of extended heavy rains.

- For road and street repair, the paper says that eliminating the deferred maintenance "can interrupt the deterioration cycle, extend the life expectancy of road surfaces, and avoid more extensive and costly maintenance."

- As justification for the $2.8 million to correct deferred traffic sign maintenance, the paper makes the point that city traffic signs have lost reflective quality. "At this point, signs may still communicate their messages adequately during daylight hours, but are ineffective after dark when safety hazards on city streets are greatest. The deterioration process is irreversible and eventually signs become so faded that they can no longer be read. In addition....many signs are knocked down, stolen or defaced. .....Missing traffic signs are a nuisance, but they are also a safety hazard. It impedes the smooth and orderly flow of traffic and, with missing street name signs for example, may hamper emergency personnel in responding to distress calls."

The section of the Issue Paper that lists the specific deferred maintenance projects proposed by each agency includes for each project a brief statement as to why the item is needed. Again, these are stated in general terms and do not contain numerical information as to the estimated amount of cost avoidance or improvement in service quality. However, they do identify the potential benefits. For example:

- For roof replacement projects the agency indicates that deteriorated roofs cause loss of installation value and high maintenance cost.

- For structural repairs to the Dallas Zoo, the repairs would assure proper health of exotic and rare animals in accordance with zoo standards and improve safety of zoo keepers.

The paper notes that it would be infeasible to correct all the deferred maintenance in one fiscal year. Thus, it prioritizes the deferred maintenance project request, putting first-priority requests into the next 1982-83, fiscal year, with the remainder to be corrected in the following years.

New York City

New York City: "Asset Condition and Maintenance Schedules for Major Portions of the City's Capital Plant: Agency Reconciliation of Maintenance Schedules; and "Asset Condition and Maintenance Schedules for Major Portions of the City's Capital Plant -- Executive Summary, both Office of the Mayor, The City of New York, May 3, 1993.

These documents are the official Mayor's report to the New York City Council required under the City Charter, which requires each agency to submit to the Mayor a condition assessment and maintenance schedule each year. This is the third such report. New York City has developed probably the most extensive and most expensive condition assessment and cost estimation process of any city in the United States. New York used contractors to help them develop the extensive condition assessment and cost estimation modeling process.

Approximately 25 percent of the city's capital assets (those with a replacement cost of at least $10 million and a useful life in excess of 10 years) are re-inspected each year. Using average costs, the agencies estimate the cost necessary to restore these assets to "a state of good repair". The report emphasized that these estimates do not give precise costs for each item but instead use average costs for each type of repair.

The report provides estimated costs for repair, replacement, and major maintenance for each department and within each department by major sub-categories. The report provides cost estimates for both expense budget (for each of the next four years) and those that would be funded out of the capital budget, (with capital budget estimates provided for the next two four-year periods). The report also provides priority ratings, based on engineer's estimates, prioritizing them into four categories: A, B, C, and D.

The report primarily covers buildings, roads, and bridges. Excluded are the Transit Authority and Water Authority, as well as other public corporations, which are excluded from the Charter reporting requirements.

How "state of good repair" is defined is not spelled out in these reports. Presumably this is determined by the City and contractors and engineers. The priority classifications are based on the importance of the item and the item's estimated time to failure. The condition status for streets is based on a scale developed by the New York State Department of Transportation, adapted for urban conditions. Pavement condition is rated on a scale from 1-10 (from almost total disrepair, i.e., greater than 75% of the surface is distressed) to a newly re-constructed street. Estimates of the condition of bridges are based on the State Department of Transportation's Bridge Inspection Reports, supplemented by brief site visits to each bridge.

San Jose, CA

San Jose (Cal.): "Infrastructure Management in San Jose," Tom Esch, Department of Public Works, San Jose, California, in APWA Reporter, October 1993; "Infrastructure Management System: Program Information", February 1993; and "City of San Jose Infrastructure Management System 1993 Status Report," November 9, 1993, both Department of Public Works, City of San Jose, California.

These papers summarize San Jose's existing and planned process to inventory, undertake condition assessment, and estimate funding needs (as well as other infrastructure tasks) for eight infrastructure areas: pavement, sanitary sewers, public buildings, traffic operations, parks, storm sewers, bridges, and landscapes. Each system uses a set of computerized models to aid in their analysis. The most highly developed systems are those for pavement, sewer, and building management systems.

In each case, the process includes an initial inventory of the items within the system that are under the city's responsibility, a condition assessment program, providing cost estimates of maintenance needs, and the development of an optimum corrective program.

The Department of Public Works provides an annual status report to the City Council that includes an estimate of current maintenance funding needs, current maintenance spending, and the average annual "unfunded maintenance needs" -- for the next ten years. The status report also gives projections as to the backlogs of maintenance and repair for the various types of infrastructure and in total. The report also compares the recommended ("optimum") funding level for the next year to the current funding level and generates an estimated amount of "additional funds needed to meet recommended standards and reduce the backlog." DPW has emphasized to the City Council that investment in preventive maintenance is less costly than major rehabilitation work.

The status report also provides limited information on the consequences of deferred maintenance. Most of the information is expressed in general terms without presenting any data, e.g., "crews become less productive by reacting only to emergencies instead of maintaining a scheduled maintenance plan" and "The frequency of corrective repairs will increase." For pavements, however, the report estimates the amount of cost avoided on pavement maintenance over the ten years if a certain amount of funding is provided (e.g., an additional $10.7 million over the ten years would avoid $68.3 million (in other expenditures) over the ten years. (p. 6 of Status report)

The status report does not, however, provide any estimates of the impacts on service quality of the unfunded maintenance. It does, however, state that not maintaining the pavement or better leads to higher user costs and increased exposure of the city to liability. (p. 25)

The following is information from the city's "Program Information" document for its sewer, pavement, and building management systems.

Sewer Management System. The city has assessed a statistical sample (three percent to ten percent) of pipe segments primarily based on TV inspections. It has developed a pipe condition rating method that assigns a score to each segment. This condition score is used to rate pipes for rehabilitation based on the relative number and severity of defects observed during the television inspection. The present worth costs of various rehabilitation alternatives are estimated and used to select the most cost-effective rehabilitation method.

The report points out that this method is useful for pipes that have already been inspected but not for other parts of the sewer system. The department makes a prediction of the condition of the entire system from the statistical sample, considering pipe condition and pipe line characteristics, such as age, material, and diameter. The model also predicts future condition by "aging" the system as part of the analysis.

DPW measures the operational level of service of the Sanitary Sewer System by the number of stoppages experienced per year, with stoppages defined as an interruption of sewer flow that impacts service to a customer. The level of service for sanitary sewer mains is based on a comparison between the existing sewage flow and the capacity of the main. Level-of-Service categories go from Service "A", the highest level of service, to Service Level "F", the least desirable service. The department's objective is to operate at Service Level "C", defined as "unrestricted sewer flow, or better."

[Note that while the statistical sample provides a sound basis for projecting the condition and needs of the sewer system, the total dollar estimate for deferred maintenance should take into account the problem that the department does not know which segments of underground pipe are in need of repair without doing an inspection. This means that to fully make such repairs, the city would also have to incur the cost of locating those pipes, a potentially expensive operation. This is a special problem for underground pipe systems, such as sewer and water supply, where an agency is not as able to readily assess the condition of the infrastructure items, such as with roads and buildings. This cost can be reduced, however, by focusing on the most at-risk pipe in terms of known age, materials, and soil conditions.]

Pavement Management System. The city surveys its surface roads to assign an "Overall Condition Number" (OCN) to each road segment. The department has determined that, by far, the most cost-effective procedure is to undertake what it calls "preventative maintenance." This calls for seal coating at the period that the road section deteriorates to the "fair" condition on the OCN scale.

The department annually estimates the "backlog cost or unfunded need," based on subtracting the amount of work actually funded from the amount of work that should be done (February 1993, page 14). The department presents to the City Council the implications of

various alternative annual pavement management budget levels including its recommended (optimum) level. For each option, DPW indicates the annual amount of work that would be required for various types of road maintenance, such as sealing, re-surfacing, reconstruction, and non-scheduled maintenance. It also estimates the average overall condition number for the network given that budget level, as well as the estimated backlog cost after a roughly ten-year period. The department also includes in this analysis for the Council an estimate of user cost under each alternative. User cost is defined as the cost to the public at large to operate vehicles on roads and poor condition. This includes an estimate of the additional fuel, oil, and maintenance cost, and the potential accident cost -- all estimated to occur because of operating on roads in poor condition. DPW has used a figure of $500 per year per car developed by the Metropolitan Transportation Commission, adjusted for the type of roads and their expected condition.

Building Management System. The city has completed initial inventory and condition assessments of 370 city buildings and facilities. This was done for major building components, including the interior and exterior finish, roof, ceiling, electrical, HVAC, plumbing, etc. Deficiency data were calculated and totaled for each building. Cost estimates were made for the major building components.

This system is just getting underway. The city hopes to define levels of service that will produce priorities for determining what should be done first. It also plans to establish procedures for continuous updating of facility condition data based on routine cyclical inspection of city facilities.

DPW is currently using the initial assessment data to develop its annual budget proposals. It has not yet developed a process for identifying optimum funding levels as done under the Pavement Management System.

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Discusses reporting decision-useful information. It explains that historical cost, or cost of asset when purchased, is not all that relevant in financial reporting. Depreciation values should not be used either in the financial reporting of infrastructure assets. The critical measure of an asset's financial condition is the ability of the capital asset to continue to provide adequate service without major expenditures for maintenance, rehabilitation, or replacement.

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This is a conceptual statement on the objectives of financial reporting by the federal government. Two reporting needs are identified that directly relate to deferred maintenance: (1) "Managers of government facilities need to know the facilities' condition and an estimate of future outlays made necessary by deferring needed maintenance" (page 31); and (2) "...the impact of the maintenance that has been deferred" (page 84 in Appendix B).

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13. ABSTRACT *(Maximum 200 words)*
This report presents the findings from an examination of public agency practices (Federal, state, and local) in analyzing and reporting deferred maintenance on their facilities, such as roads, bridges, buildings, water or sewer systems, etc. The study examined existing literature, and followed up on a number of past and active Federal, state, and local agency efforts (including field visits to review the activities in New York City and San Jose, California). The study found a limited amount of literature on ongoing efforts by public agencies directly addressed to the analysis and reporting of deferred maintenance.

The literature and field interviews make a strong case for reporting annually the amount of deferred maintenance. Such information is needed for proper stewardship of public assets and can provide information to help public officials make more informed judgements as to the allocation of scarce public resources.

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